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# THE DISTRIBUTION AND ABUNDANCE OF MAY BEETLES IN OHIO

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# PREFACE

For a number of years, beginning about 1932, the writer has been involved in a study of the *Phyllophaga* of Ohio. The investigations have been concerned with the species present in Ohio and their distribution and abundance over the state. The data have been accumulated by hand collections made at night using flashlights and by the seasonal operation of light traps in selected localities. During more recent years, when the writer was engaged in other work, Dr. J. B. Polivka has made collections of *Phyllophaga* in association with his ecological study of the Japanese beetle and other soil inhabiting insects. The writer and Dr. Polivka have both made *Phyllophaga* collections at widely distributed areas over the state.

During the same period, Dr. Edward S. Thomas, Curator of Natural History at the Ohio State Museum in Columbus (now emeritus), and Dr. W. C. Stehr of the Department of Entomology at Ohio University, Athens, Ohio, have also been interested in *Phyllophaga* distribution. Dr. Thomas, with the assistance of Charles F. Walker, John S. Thomas, Robert M. Goslin and others, has made statewide collections with greatest emphasis in central Ohio. Dr. Stehr has concentrated his attention in southern Ohio in the area around Athens but has also collected in other parts of the state.

All species identifications were verified by Dr. Philip Luginbill while he was still active, and all of the species taken in these investigations were entered for Ohio in United States Department of Agriculture Technical Bulletin 1060 published by Luginbill and Painter on the May Beetles of the United States and Canada.

Thomas, Stehr and Polivka have graciously turned their species collection records over to the writer for assembling and for publication. Their contributions are greatly appreciated.

Specimens on which records are based are in the collections of The Ohio State University, the Ohio State Museum, Ohio University and the Ohio Agricultural Experiment Station, Wooster.

In order that students may associate *Phyllophaga* species distribution with the physiographic features of the state, a map prepared originally by Professor G. D. Hubbard and published in The Geography of Ohio by Roderick Peattie was later reproduced with modifications by Roger Conant in The Reptiles of Ohio (1951, p. 279) and is presented here as Figure 1.

C. R. Neiswander

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# THE DISTRIBUTION AND ABUNDANCE OF MAY BEETLES IN OHIO

C. R. NEISWANDER*

The May beetles, *Phyllophaga* spp., and their young, the common white grubs, have been of important concern to agriculture in some parts of Ohio ever since the production and cultivation of crops was first undertaken. The adult beetles feed on and sometimes defoliate a great many species of trees and shrubs including the oaks, hickory, walnut, birch, willow, elm and many others. The feeding of the beetles is done at night and home owners frequently have had trees and shrubs defoliated without any knowledge of the insects responsible for the injury. Characteristic defoliation is shown in Figures 2 and 3. It may be noted in Figure 2 that maples were not injured.

The grubs of May beetles are primarily grass root feeders. They are native to the United States and were undoubtedly abundant in the prairie grasses at the time America was discovered. They attain their greatest accumulation in Ohio in blue grass lawns and pastures (Figure 4). However, they do severe damage to corn (Figures 5 and 6), potatoes, strawberries, and other crops when such crops follow blue grass that has been infested with grubs. Outside of turf areas, their damage is more conspicuous in cultivated row crops, such as corn or potatoes, than in full coverage crops, such as wheat or oats.

To date, 36 species of May beetles are recorded as having been taken in Ohio. Of these some are abundant and widely distributed over the state, whereas others have been taken rarely and their records of distribution have been restricted to local areas.

The men of each of the three agencies whose collection records are included in this report have each taken species that neither of the other two have had. The writer has taken *Phyllophaga nitida* at Steubenville in eastern Ohio, *P. longitarsa* in southern Ohio and *P. prunina* in the oak barrens west of Toledo. Dr. Thomas of the Ohio State Museum has taken *P. bipartita* and *P. kentuckiana* in southern Ohio, *P. spreta* and *P. inepta* in southwestern Ohio and *P. gracilis* in northwestern Ohio. Dr. Stehr of Ohio University has taken *P. diffinis* in southern Ohio. Stehr and Thomas have both taken *P. delata* in different areas in central and southwestern Ohio, Thomas and the writer have both taken *P. longispina* in northeastern Ohio, and Stehr and the writer have both taken *P. vehemens* in southwestern Ohio. The rare *P. albina* was taken many years ago at Cincinnati by Charles Dury and more recently at Clifton Gorge by J. N. Knull. Most of the common and widely distributed species were taken by all four of the collectors.

It is probable that with more extensive collecting, the range of distribution of the less abundant species will be greatly increased. It is possible, also, that additional species will be taken. A listing of the 36 species taken to date in Ohio is given below. The known area distribution records for the various species within the state are given on maps beginning on page 33.

### A Check List of the Species of *Phyllophaga* Taken in Ohio

*P. albina* (Burmeister)
*P. anxia* (LeConte)
*P. balia* (Say)
*P. barda* (Horn)
*P. bipartita* (Horn)
*P. crenulata* (Froelich)
*P. delata* (Horn)
*P. diffinis* (Blanchard)
*P. drakei* (Kirby)
*P. ephilida* (Say)
*P. fervida* (Fabricius)
*P. forsteri* (Burmeister)
*P. fraterna* (Harris)
*P. fusca* (Froelich)
*P. futilis* (LeConte)
*P. gracilis* (Burmeister)
*P. hirticula* (Knoch)
*P. hornii* (Smith)
*P. ilicis* (Knoch)
*P. implicita* (Horn)
*P. inepta* (Horn)
*P. inversa* (Horn)
*P. kentuckiana* Ritcher
*P. longispina* (Smith)
*P. longitarsa* (Say)
*P. marginalis* (LeConte)
*P. micans* (Knoch)
*P. nitida* (LeConte)
*P. pearliae* Davis
*P. prunina* (LeConte)
*P. quercus* (Knoch)
*P. rugosa* (Melsheimer)
*P. spreta* (Horn)
*P. tristis* (Fabricius)
*P. vehemens* (Horn)
*P. vilifrons* (LeConte)

The May beetle species vary somewhat in size and color as shown in Figure 7, but many species can be identified only by examining the genitalia. The differentiating characters for the species taken in Ohio have been described and figured by a number of authors (Luginbill and Painter 1953, Sim 1928 and Ritcher 1940) and are not repeated here.

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## SEASONAL BEHAVIOR

With one or two possible exceptions the May beetles have a three-year life cycle in Ohio. This means that if a group of May beetles are depositing eggs in any one year, the insects hatching from the eggs will not again deposit eggs until three years later. All of the May beetles that occur in any one year are known as a brood regardless of the number of species involved. The beetles in flight in 1962 were known as Brood A, those in 1963 are Brood B and those in 1964 will be Brood C. Brood A will again be in flight in 1965, Brood B in 1966 and Brood C in 1967, and each will reappear in corresponding years.

The grub damage year for each brood is one year later than the beetle flight year. That is, the grubs do their greatest amount of feeding on the roots of plants during the second year of their existence as grubs. During the first year they are too small to cause important injury and during the third year they feed for only a few weeks before changing to the inactive pupal stage.

In the United States the May beetles are most abundant over the eastern half of the country. Inasmuch as the adults feed on the foliage of trees and shrubs, it would seem that trees or shrubs would be essential for the build-up of a severe grub infestation. Forbes (1916) showed a direct correlation between the nearness of trees and the intensity of grub infestation. He found that there were 2¾ times as many grubs in fields with trees as close as 40 rods than there were when the nearest trees were half a mile away.

White grubs were particularly abundant over much of the north central states region in 1909, 1912 and 1915 following an extraordinary flight of May beetles in the years 1908, 1911 and 1914. It was at that time that the most abundant brood was given the name Brood A and the lesser successive broods were designated as Broods B and C. Because of the severe outbreaks that occurred during that period, extensive study was given to May beetle and white grub populations and damage. Since that time Brood A has usually been considered the most abundant and most destructive brood with Brood C of secondary importance and Brood B of third, but only minor importance. Entomologists have essentially accepted the early alignment of broods without subsequent study of populations, and in some areas farmers are still warned of damage to be expected from Brood A.

In Ohio, where fluctuations in May beetle populations have been observed over the past thirty years, the importance of the different broods has varied greatly. At one time the A Brood was the most abundant; later it was replaced by the C Brood and at present none of the three broods are of severe economic importance. The insects are very susceptible to changes in ecological conditions, particularly soil moisture, and accordingly brood populations can change quickly. These fluctuations will be shown in the following paragraphs.

## FLUCTUATIONS IN BROOD ABUNDANCE IN OHIO

In 1925, Dr. C. R. Cutright of the Entomology Department at the Ohio Agricultural Experiment Station reviewed the correspondence of the Department pertaining to white grub injury. Letters requesting information on white grubs during the years 1917 to 1925 were marked on maps showing the sources of the letters and the years they were received. The results are shown on Ohio maps (Figure 8). The maps indicate that for the nine-year period the grub problems were accentuated during the years 1918, 1921, and 1924, or the years in which the A Brood was in its most destructive stage. This finding was never published but it tended to corroborate the consensus that the A Brood was the most important brood in Ohio as in other mid-western states. It may noted that the records also indicate that the area of greatest abundance occurred along a diagonal line across the state from northeast to southwest. The concentration of population seemed to be associated with the glaciated portion of the state adjacent to the glacial boundary (Figure 1).

In 1934, the writer reviewed the Department correspondence for the preceeding 15 years (1920-34) and compiled the information by broods so that there were five-year accumulation records for each of the three broods. The records are shown in Figures 9, 10, and 11. It may be noted that for the period as a whole the correspondence seemed to indicate that the A Brood was still the most abundant and B the least abundant brood; but that Brood C was approaching Brood A in numbers. It may be noted also that for all three broods the infestation was most pronounced in Stark County in eastern Ohio and that the infestation again followed a diagonal line across the state from northeast to southwest. But few reports have been received from the southeastern unglaciated areas of the state and relatively few from the northwestern lake plains. However, light traps that were operated in or near forest areas in the extreme southern part of the state yielded more species and fairly large number of beetles regardless of the brood in flight. Inasmuch as southern and southeastern Ohio is a hilly grassland area, it is possible that the low intensity of farming may account for the few letters requesting information in that area.

Relatively few letters were received from the heavily farmed extreme western Ohio except for the restricted "oak barrens" west of Toledo. On the other hand, Stark County in northeastern Ohio seems to have had a continuous white grub problem during that period. The writer's personal contact with farmers in the area tends to corroborate the continuous problem status of the county at that time. However, in recent years grub damage in Stark County has been greatly alleviated.

Of the 334 white grub letters received during the period 1920-34, 30 percent were concerned with injury to strawberries, 22 percent to lawns, 20 percent to corn and 15 percent to potatoes. The remaining 13 percent were concerned with wheat, oats, meadow and garden and nursery crops.

## MAY BEETLE TRAPPING RECORDS

For most of the period from 1933 through 1955, light traps were operated through the May beetle flight season at Wooster in the northeastern part of the state and at Marietta in the hilly southeastern part. During most of this period, two traps were operated at Wooster, one on the Experiment Station campus and one near the arboretum. Although the cropping system in the vicinity of the Wooster traps varied from year to year, there was always an extensive blue grass turf near the trapping area. The total beetle capture per trap in the two areas is shown in Figures 12 and 13. It may be noted that Brood C was by far the most abundant brood in the Wooster area during the late 1930's and early 1940's. In fact, in years of May beetle or white grub outbreaks, regardless of the brood, Wooster (Wayne County) has usually been within the severely infested area. The light trap record taken at Marietta shows considerable fluctuation in the numbers of beetles captured in the A and C broods during the period 1932-1950. However, after 1950, all broods were at a relatively low level and practically equal (Figure 13).

During the period 1937-1942, a series of light traps was operated at widely distributed points in Ohio to obtain more conclusive information on the distribution of May beetles in Ohio and the relative importance of the three broods. Inasmuch as trapping records were taken during six consecutive years, each brood was trapped twice. The traps were operated in 15 localities but not all of them were in operation every year because of local difficulties. The distribution of the traps over the state is shown in Figure 14.

The trap used throughout this study was a funnel type trap operated by a 100 watt Mazda lamp mounted on a steel post approximately five feet above the ground as shown in Figure 15. The traps were set up in an open area but near enough to buildings to provide electric current. The summation of data from this series of traps is presented in Table 1.

It may be noted that approximately three times as many beetles were captured during the years the C Brood was in flight as were taken during the flights of A and B Broods. The data therefore show that the C Brood was by far the most abundant brood in Ohio during this six-year period. In 1937 and again in 1940, there was extensive defoliation of trees in the area as shown in Figures 2 and 3. In like manner in the succeeding C Brood years, 1938 and 1941, there was severe damage to lawns, pastures and cultivated crops in the same general area. Many permanent blue grass pastures were essentially destroyed. A field of corn in a fertility test on the Experiment Station Farm in 1941 had an average of 12.4 grubs per hill in August. In addition, skunks had made diggings at practically every hill and had undoubtedly taken additional grubs. Needless to say, the corn was very severely damaged if not a total loss. The approximate range of the area in which extensive defoliation of trees was observed in 1937 is shown in Figure 16. Defoliation was repeated in essentially the same area in 1940.

It may be noted also from Table 1, that over the state as a whole, *P. futilis* was the species taken most frequently. However, this species was seldom taken at Wooster. The species in second, third, and fourth place were *P. rugosa, P. fusca* and *P. hirticula*. These species were abundant throughout the severely infested area and were largely responsible for severe defoliation of trees and damage to crops.

In Tables 2 and 3 are shown the May beetle species collected and the numbers of individuals per species in light traps at Wooster and Marietta respectively, through the years 1935 to 1955. It may be noted that there was considerable difference in the abundance of the various species in the two areas. In the Wooster traps the most abundant species were *P. rugosa, P. fusca* and *P. hirticula*. In fact, these three species made up more than 95 percent of the total capture. At Marietta, the most abundant species were *P. rugosa, P. futilis* and *P. fervida*. However, these three species made up only about 58 percent of the total capture in that area. The species *P. fervida* seems to be confined largely to the southern half of the state. It has not been taken by the writer at Wooster, although it has been taken in Richland and Hardin counties which are nearly of the same latitude as Wooster. From Columbus southward, it has been one of the more abundant species.

It may be noted from Table 2 that the C Brood numbers at Wooster dropped nearly 90 percent between 1940 and 1946. After 1946 they continued to remain at a low level. At Marietta, Table 3, the C Brood was still abundant in 1949 but after that declined rapidly.

## BEETLE FLIGHT SEASON

The time of May beetle flight varies greatly with the season and also with the species. On the average they are in flight in Ohio from about the middle of May to the middle of June. They are usually a week to 10 days earlier at Marietta in southern Ohio than they are at Wooster. In some years there is extensive beetle flight during the last few days of April, whereas in other years, the major flight may come in June with a considerable carry over into July.

*P. tristis, P. fusca,* and *P. futilis* were among the earlier species taken, whereas *P. crenulata, P. ephilida* and *P. quercus* were always late. *P. crenulata* has never been abundant but has been taken fairly consistently in southern Ohio throughout June and much of July. *P. quercus* and *P. ephilida,* both of which seem to be confined to the southern half of the state, have been taken most often in July and rarely in June.

The beetle trapping records for selected localities and certain years are shown in Tables 4 to 8. In order to conserve space, only a few records are given and all collections are condensed into two-week intervals. It may be noted in the Shawnee Forest records (Tables 6 to 8) no species dominated the collection but the number of species taken was greater than in any of the other localities. On the other hand, at Painesville, (Table 7) *P. futilis* and *P. rugosa* made up 90 percent of the collection and at Wooster (Table 4) more than 97 percent of the individuals taken were *P. rugosa, P. fusca,* and *P. hirticula.*

The ratio between the sexes taken at light traps has varied greatly but always with a preponderance of males. The ratio of males to females for the different species has varied from about 1½:1 to 20:1. The relatively abundant *P. futilis* has consistently shown a preponderance of 10 or 12 males to one female.

## KNOWN DISTRIBUTION OF *PHYLLOPHAGA* IN OHIO

In the following outline maps of the state of Ohio, the known distribution for the various species taken within the state is recorded. The location record is given by townships. That is, if a certain species was taken within a township, that township was marked in black on the map. The distribution record is the sum total for all species collected by whatever means used and by all of the investigators listed in the preface to this bulletin.

It may be noted that the four species taken most abundantly in light traps, namely *P. futilis, P. hirticula, P. rugosa,* and *P. fusca,* were also the most widely distributed species. Each of these species was taken at most of the approximately 125 collection sites. *P. fraterna* was also taken in most of the collection sites but in no case was it abundant. On the other hand, a number of the species were taken in only a single locality.

## LITERATURE CITED


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Ritcher, P. O. 1940. Kentucky White Grubs. Kentucky Agri. Exp. Sta. Bul. 401.

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Table 1. Total Light Trap Collections, Phyllophaga spp.
1937 - 1942

| No. | Species | Number of Beetles by Years and Broods | | | | | | Totals |
|---|---|---|---|---|---|---|---|---|
| | | 1937-(C) (11 traps) | 1938-(A) (12 traps) | 1939-(B) (13 traps) | 1940-(C) (14 traps) | 1941-(A) (14 traps) | 1942-(B) (12 traps) | |
| 1 | P. futilis | 2846 | 1050 | 2383 | 7831 | 4659 | 3129 | 21898 |
| 2 | rugosa | 2457 | 662 | 718 | 5286 | 1981 | 787 | 11891 |
| 3 | hirticula | 1865 | 159 | 472 | 2120 | 264 | 519 | 5399 |
| 4 | fusca | 1128 | 106 | 603 | 2399 | 388 | 776 | 5400 |
| 5 | ilicis | 42 | 298 | 171 | 831 | 336 | 62 | 1740 |
| 6 | balia | 427 | 21 | 139 | 706 | 55 | 313 | 1661 |
| 7 | implicita | 158 | | 257 | 332 | 261 | 138 | 1146 |
| 8 | fervida | 314 | 63 | 221 | 180 | 234 | 51 | 1063 |
| 9 | inversa | 235 | 56 | 77 | 300 | 140 | 147 | 955 |
| 10 | crenulata | 202 | 38 | 45 | 140 | 64 | 34 | 523 |
| 11 | fraterna | 66 | 5 | 29 | 219 | 32 | 69 | 420 |
| 12 | anxia | 83 | 7 | 38 | 182 | 71 | 16 | 397 |
| 13 | forsteri | 61 | 22 | 15 | 117 | 17 | 28 | 260 |
| 14 | barda | 1 | 12 | 40 | 180 | 10 | 4 | 247 |
| 15 | marginalis | 9 | 4 | 5 | 161 | 4 | 49 | 232 |
| 16 | ephilida | 67 | 1 | 8 | 6 | 114 | 12 | 208 |
| 17 | tristis | | 21 | 22 | 36 | 26 | 70 | 175 |
| 18 | drakei | 25 | 32 | 10 | 53 | 28 | 4 | 152 |
| 19 | hornii | 3 | 3 | 6 | 85 | 3 | 43 | 143 |
| 20 | vilifrons | 2 | 6 | 6 | 28 | 13 | 2 | 57 |
| 21 | quercus | 1 | 5 | 5 | 22 | 5 | 5 | 43 |
| 22 | micans | 3 | 2 | 3 | 1 | | 24 | 33 |
| 23 | longispina | 4 | 2 | | 13 | 1 | 1 | 21 |
| 24 | vehemens | 1 | | | | | | 1 |
| 25 | longitarsa | 1 | | | | | | 1 |
| 26 | nitida | | | | 1 | | | 1 |
| | Totals | 10001 | 2575 | 5273 | 21229 | 8706 | 6283 | 54067 |

Table 2. Total May Beetles Collected By Brood and Year in Light Traps at Wooster, Ohio. 1936 - 1955.

| Species | B 1936 | C 1937 | A 1938 | B 1939 | C 1940 | A 1941 | B 1942 | C 1946 | C 1949 | B 1951 | C 1952 | A 1953 | B 1954 | C 1955 | Tot. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| P. rugosa | 61 | 1568 | 195 | 113 | 1836 | 161 | 106 | 370 | 109 | 48 | 114 | 2 | 338 | 89 | 5110 |
| P. fusca | 244 | 84 | 23 | 430 | 1304 | 60 | 263 | 16 | 46 | 32 | 10 | 3 | 147 | 15 | 2677 |
| P. hirticula | 19 | 1167 | 41 | 61 | 921 | 13 | 29 | 92 | 10 | 1 | 8 | 0 | 25 | 9 | 2396 |
| P. futilis | 1 | 2 | 2 | 1 | 2 | 0 | 1 | 0 | 3 | 5 | 4 | 1 | 47 | 1 | 70 |
| P. fraterna | 1 | 33 | 0 | 1 | 24 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 62 |
| P. forsteri | 1 | 27 | 1 | ? | 13 | 5 | 3 | 0 | 1 | 0 | 1 | 0 | 3 | 2 | 59 |
| P. anxia | 1 | 5 | 0 | 0 | 13 | 0 | 1 | 4 | 2 | 1 | 3 | 0 | 9 | 0 | 39 |
| P. inversa | 0 | 2 | 3 | 3 | 17 | 1 | 3 | 6 | 2 | 1 | 1 | 0 | 8 | 1 | 48 |
| P. ilicis | 0 | 22 | 4 | 2 | 6 | 2 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 38 |
| P. tristis | 1 | 4 | 3 | 2 | 11 | 0 | 7 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 30 |
| P. balia | 4 | 2 | 1 | 2 | 6 | 2 | 6 | 1 | 0 | 0 | 2 | 0 | 1 | 1 | 28 |
| P. longispina | 1 | 3 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 |
| P. marginalis | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| P. vilifrons | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Totals | 334 | 2921 | 273 | 617 | 4155 | 247 | 419 | 491 | 175 | 88 | 143 | 6 | 578 | 118 | 10565 |

Note: Trapping records not consecutive after 1942.

Table 3. Total May Beetles Collected By Brood and Year in a Light Trap at Marietta, Ohio. 1935 - 1955.

| Species | A 1935 | C 1937 | A 1938 | B 1939 | C 1940 | A 1941 | B 1942 | C 1946 | B 1948 | C 1949 | B 1951 | C 1952 | A 1953 | B 1954 | C 1955 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| P. rugosa | 114 | 422 | 56 | 78 | 396 | 382 | 167 | 187 | 135 | 465 | 171 | 40 | 65 | 33 | 54 | 2765 |
| P. futilis | 382 | 539 | 72 | 123 | 103 | 138 | 33 | 4 | 38 | 197 | 68 | 10 | 26 | 17 | 0 | 1750 |
| P. fervida | 439 | 312 | 56 | 208 | 139 | 231 | 460 | 21 | 21 | 65 | 67 | 4 | 9 | 13 | 1 | 1632 |
| P. implicita | 0 | 3 | 0 | 20 | 2 | 62 | 7 | 57 | 47 | 278 | 208 | 15 | 166 | 15 | 25 | 905 |
| P. crenulata | 31 | 174 | 7 | 12 | 94 | 33 | 24 | 60 | 21 | 39 | 26 | 47 | 29 | 19 | 43 | 659 |
| P. fusca | 82 | 42 | 13 | 44 | 26 | 26 | 2 | 0 | 7 | 19 | 10 | 4 | 7 | 3 | 0 | 285 |
| P. hirticula | 135 | 16 | 3 | 16 | 17 | 23 | 12 | 5 | 0 | 19 | 16 | 1 | 5 | 0 | 0 | 268 |
| P. fraterna | 41 | 10 | 2 | 5 | 20 | 9 | 4 | 14 | 1 | 25 | 26 | 2 | 1 | 14 | 2 | 176 |
| P. balia | 3 | 19 | 0 | 6 | 22 | 4 | 3 | 0 | 2 | 6 | 2 | 1 | 2 | 5 | 0 | 75 |
| P. anxia | 9 | 17 | 0 | 1 | 4 | 0 | 1 | 0 | 2 | 11 | 4 | 0 | 2 | 0 | 4 | 55 |
| P. quercus | 0 | 0 | 2 | 1 | 14 | 2 | 1 | 1 | 1 | 4 | 7 | 4 | 3 | 0 | 0 | 40 |
| P. forsteri | 0 | 3 | 0 | 0 | 8 | 0 | 0 | 4 | 0 | 2 | 5 | 0 | 0 | 1 | 0 | 23 |
| P. hornii | 0 | 3 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 7 | 0 | 0 | 1 | 2 | 0 | 15 |
| P. marginalis | 0 | 0 | 0 | 1 | 7 | 0 | 2 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 2 | 15 |
| P. ilicis | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 3 |
| P. vilifrons | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| P. tristis | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 2 |
| P. drakei | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Totals | 1238 | 1560 | 211 | 515 | 855 | 910 | 303 | 354 | 276 | 1138 | 613 | 128 | 317 | 122 | 131 | 8671 |

Table 4. Total May Beetles Collected By Two-Week Intervals in Light Traps at Wooster, Ohio. 1937

| Species | Sex | April 16-30 | May 1-15 | May 16-30 | May 31-13 | June 14-28 | June 29-12 | July 13-27 | Totals |
|---|---|---|---|---|---|---|---|---|---|
| P. fusca | M | | 30 | 120 | 589 | 60 | 1 | | 800 |
| | F | | 1 | 26 | 68 | 14 | 1 | | 110 |
| P. rugosa | M | | 4 | 98 | 891 | 88 | 23 | 1 | 1105 |
| | F | | 1 | 8 | 167 | 17 | 19 | | 212 |
| P. hirticula | M | | 4 | 71 | 436 | 34 | 3 | 2 | 550 |
| | F | | 2 | 50 | 228 | 41 | 9 | 1 | 331 |
| P. fraterna | M | | 1 | 8 | 11 | 3 | 6 | | 29 |
| | F | | | | 2 | | | | 2 |
| P. inversa | M | | | | 1 | | | | 1 |
| | F | | | | | | | | 0 |
| P. anxia | M | | | 1 | | | | | 1 |
| | F | | | | | | | | 0 |
| P. longispina | M | | | | 1 | | | | 1 |
| | F | | 1 | | | | | | 1 |
| P. forsteri | M | | | | 7 | 8 | 5 | | 20 |
| | F | | | | 1 | | | | 1 |
| P. ilicis | M | | | | 11 | 2 | 4 | | 17 |
| | F | | | | 1 | | | | 1 |
| P. balia | M | | | | 2 | | | | 2 |
| | F | | | | | | | | 0 |
| P. futilis | M | | | | | | | | 1 |
| | F | | | 1 | | | | | 0 |
| P. marginalis | M | | | | 1 | 1 | | | 2 |
| | F | | | | | | | | 0 |
| Total | | | | | | | | | 3187 |

Table 5. Total May Beetles Collected By Two-Week Intervals in a Light Trap at Marietta, Ohio. 1937

| Species | Sex | April 16-30 | May 1-15 | May 16-30 | May 31-13 | June 14-28 | June 29-12 | July 13-27 | Total |
|---|---|---|---|---|---|---|---|---|---|
| P. futilis | M | | 192 | 256 | 10 | 2 | | | 460 |
| | F | | 23 | 48 | 7 | 1 | | | 79 |
| P. fervida | M | | 23 | 97 | 76 | | | | 196 |
| | F | | 8 | 32 | 71 | 5 | | | 116 |
| P. rugosa | M | | 11 | 193 | 124 | 5 | | | 333 |
| | F | | 2 | 48 | 36 | 3 | | | 89 |
| P. hirticula | M | | 1 | 3 | 5 | | | | 9 |
| | F | | | 2 | 4 | 1 | | | 7 |
| P. fusca | M | | 7 | 21 | 5 | | | | 33 |
| | F | | | 4 | 5 | | | | 9 |
| P. fraterna | M | | 1 | 5 | 3 | 1 | | | 10 |
| | F | | | | | | | | 0 |
| P. balia | M | | 1 | 7 | 10 | | | | 18 |
| | F | | | | 1 | | | | 1 |
| P. anxia | M | | 2 | 11 | 4 | | | | 17 |
| | F | | | | | | | | 0 |
| P. crenulata | M | | | 7 | 51 | 63 | 37 | 1 | 159 |
| | F | | | 2 | 4 | 9 | 1 | | 16 |
| P. forsteri | M | | | 1 | 1 | 1 | | | 3 |
| | F | | | | | | | | 0 |
| P. ilicis | M | | | 1 | 2 | | | | 3 |
| | F | | | | | | | | 0 |
| P. hornii | M | | | | 3 | | | | 3 |
| | F | | | | | | | | 0 |
| Total | | | | | | | | | 1561 |

Table 6. Total May Beetles Collected By Two-Week Intervals in a Light Trap at Shawnee Forest, Portsmouth, Ohio. 1937

| Species | Sex | April 16-30 | May 1-15 | May 16-30 | May 31-13 | June 14-28 | June 29-12 | July 13-27 | Totals |
|---|---|---|---|---|---|---|---|---|---|
| P. balia | M | | | 271 | 128 | 1 | | | 400 |
| | F | | | | 1 | | | | 1 |
| P. futilis | M | | | 66 | 16 | 5 | 1 | | 88 |
| | F | | | 3 | 7 | | | | 10 |
| P. forsteri | M | | | 11 | 8 | 1 | 4 | 3 | 27 |
| | F | | | | 3 | 2 | | | 5 |
| P. hirticula | M | | | 6 | 13 | 1 | 3 | | 23 |
| | F | | | 3 | 6 | 1 | 1 | | 11 |
| P. fusca | M | | | 36 | 21 | 2 | | | 59 |
| | F | | | 3 | 5 | 1 | | | 9 |
| P. rugosa | M | | | | 1 | | | | 1 |
| | F | | | | | | | | 0 |
| P. anxia | M | | | 15 | 5 | 1 | | | 21 |
| | F | | | | 1 | | | | 1 |
| P. drakei | M | | | 2 | 4 | 3 | 11 | 5 | 25 |
| | F | | | | | 1 | | | 1 |
| P. ilicis | M | | | | 6 | 1 | 2 | | 9 |
| | F | | | | | | | | 0 |
| P. micans | M | | | | 2 | 1 | | | 3 |
| | F | | | | | | | | 0 |
| P. fervida | M | | | | | | | | 0 |
| | F | | | | 1 | | | | 1 |
| P. marginalis | M | | | 5 | | | 2 | | 7 |
| | F | | | | | | | | 0 |
| P. vilifrons | M | | | 1 | 1 | | | | 2 |
| | F | | | | | | | | 0 |
| P. crenulata | M | | | | | | 1 | | 1 |
| | F | | | | | | | | 0 |
| P. ephilida | M | | | | | | 3 | 57 | 60 |
| | F | | | | | | 5 | 1 | 6 |
| P. quercus | M | | | | | | | 1 | 1 |
| | F | | | | | | | | 0 |
| P. longispina | M | | | | | | | | 0 |
| | F | | | | | | 1 | | 1 |
| P barda | M | | | | 1 | | | | 1 |
| | F | | | | | | | | 0 |
| Total | | | | | | | | | 774 |

Table 7. Total May Beetles Collected By Two-Week Intervals in a Light Trap at Painesville, Ohio. 1942

| Species | Sex | April 16-30 | May 1-15 | May 16-30 | June 31-13 | June 14-28 | July 29-12 | July 13-27 | Totals |
|---|---|---|---|---|---|---|---|---|---|
| P. rugosa | M | | 114 | 65 | 80 | 28 | 1 | | 288 |
| | F | | 11 | 6 | 14 | 3 | 1 | | 35 |
| P. hirticula | M | | 6 | 6 | 4 | | | | 16 |
| | F | | 4 | 5 | 3 | 2 | | | 14 |
| P. balia | M | | 2 | | | | | | 2 |
| | F | | | | | | | | 0 |
| P. futilis | M | 59 | 451 | 202 | 179 | 37 | | | 928 |
| | F | 4 | 11 | 5 | 11 | 2 | 3 | | 36 |
| P. fusca | M | 1 | 44 | 17 | 4 | 2 | | | 68 |
| | F | | 2 | 2 | | | | | 4 |
| P. fraterna | M | | 1 | 1 | 1 | 1 | | | 4 |
| | F | | | | | | | | 0 |
| P. crenulata | M | | 2 | 2 | 2 | 1 | | | 7 |
| | F | | | | | 1 | | | 1 |
| P. anxia | M | | 4 | 1 | 3 | | | | 8 |
| | F | | 1 | | | | | | 1 |
| P. tristis | M | | 8 | 1 | | | | | 9 |
| | F | | 4 | 1 | | | | | 5 |
| P. longispina | M | | 1 | | | | | | 1 |
| | F | | | | | | | | 0 |
| Total | | | | | | | | | 1427 |

Table 8. Total May Beetles Collected By Two-Week Intervals in a Light Trap at Shawnee Forest, Portsmouth, Ohio. 1942

| Species | Sex | April | May | | June | | July | | Totals |
|---|---|---|---|---|---|---|---|---|---|
| | | 16-30 | 1-15 | 16-30 | 31-13 | 14-28 | 29-12 | 13-27 | |
| P. micans | M | | 3 | 8 | 6 | | 1 | | 18 |
| | F | | | 1 | 4 | 1 | | | 6 |
| P. balia | M | | 107 | 12 | 37 | 1 | 6 | | 163 |
| | F | | 3 | | 2 | | | | 5 |
| P. hirticula | M | 6 | 67 | 31 | 31 | 2 | 6 | 1 | 144 |
| | F | 6 | 23 | 7 | 31 | 1 | 4 | 1 | 73 |
| P. ilicis | M | | | 2 | 14 | 3 | 1 | | 20 |
| | F | | | | 1 | | | | 1 |
| P. quercus | M | | | | | | | 4 | 4 |
| | F | | | | | | | | 0 |
| P. ephilida | M | | | | | | 1 | 10 | 11 |
| | F | | | | | | | | 0 |
| P. forsteri | M | 2 | 4 | 5 | 3 | 1 | 1 | 1 | 17 |
| | F | | 1 | 2 | 2 | | 1 | | 6 |
| P. fraterna | M | 1 | 20 | 11 | 11 | 8 | 2 | 1 | 54 |
| | F | | 1 | | | 1 | | | 2 |
| P. fusca | M | | 6 | 5 | 2 | | | | 13 |
| | F | 1 | 5 | 3 | | | 1 | | 10 |
| P. marginalis | M | | | 12 | 1 | 1 | | | 14 |
| | F | | | 5 | | | | | 5 |
| P. fervida | M | | | 1 | | | | | 1 |
| | F | | | 1 | 1 | | | | 2 |
| P. tristis | M | 6 | 6 | 1 | | | | | 13 |
| | F | 6 | 9 | | | | | | 15 |
| P. rugosa | M | | 3 | 1 | 1 | | 2 | | 7 |
| | F | | 1 | | | | | | 1 |
| P. inversa | M | | 1 | 2 | 1 | | | | 4 |
| | F | | | | | | | | 0 |
| P. drakei | M | | | 1 | 1 | 1 | | | 3 |
| | F | | | | | | | | 0 |
| P. barda | M | | | 2 | | | | | 2 |
| | F | | | | | | | | 0 |
| Total | | | | | | | | | 614 |


Fig. 1.—Physiographic features of Ohio. The serrated line denotes the glacial boundary. (Map reproduced with permission from The Reptiles of Ohio, Second Edition, by Roger Conant as published by the American Midland Naturalist, 1951).

Fig. 2.—Hillside in Stark County showing oaks and hickories defoliated by May beetles. Note that maples are not injured.

Fig. 3.—Oak trees defoliated by May beetles in 1937 in Stark County.

Fig. 4.—Section of turf lifted up to show abundance of grubs underneath. It may be noted that the grass has been almost completely severed from the roots.

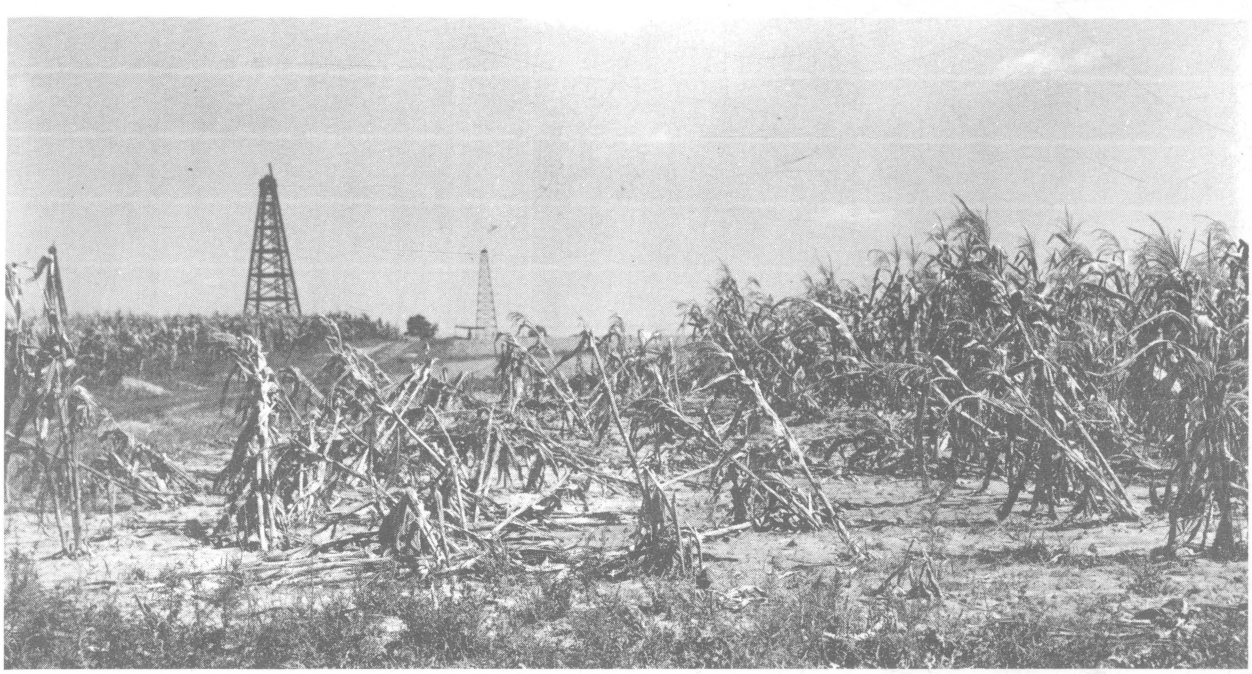


Fig. 5.—Section of corn field showing severe lodging due to white grub injury.

Fig. 6.—Earth partially removed from around base of lodged corn plant to show presence of grubs.

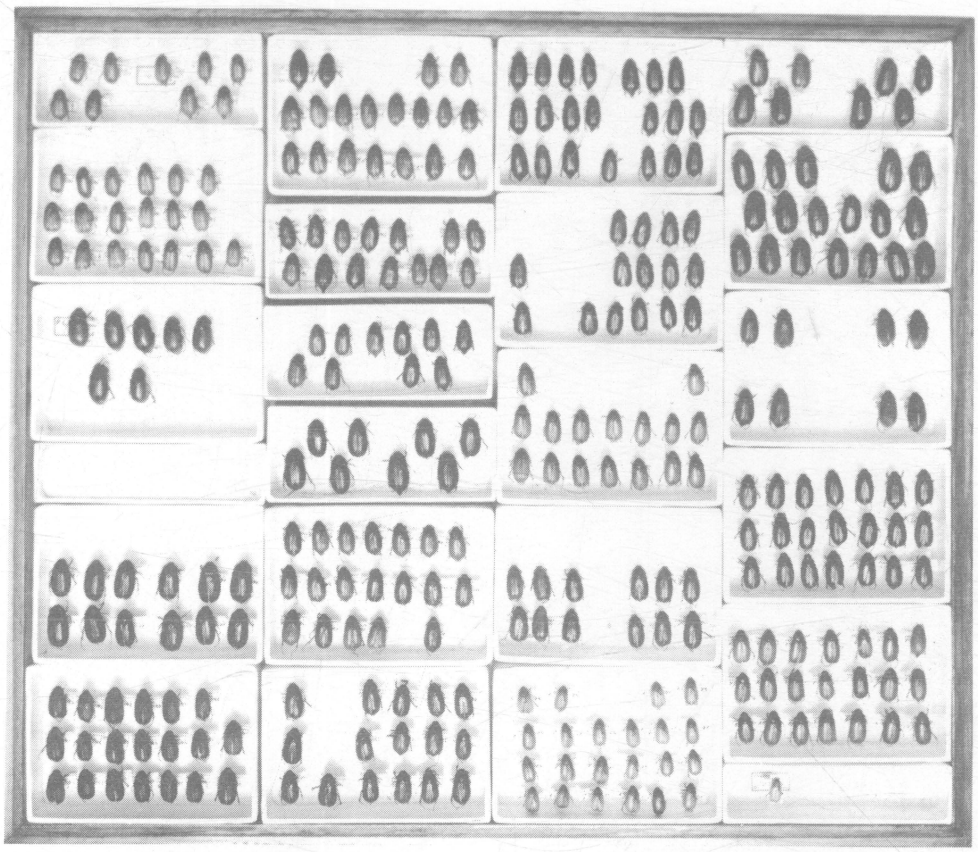


Fig. 7.—Tray of May beetle species showing variation in size and color. Each box contains a single species.

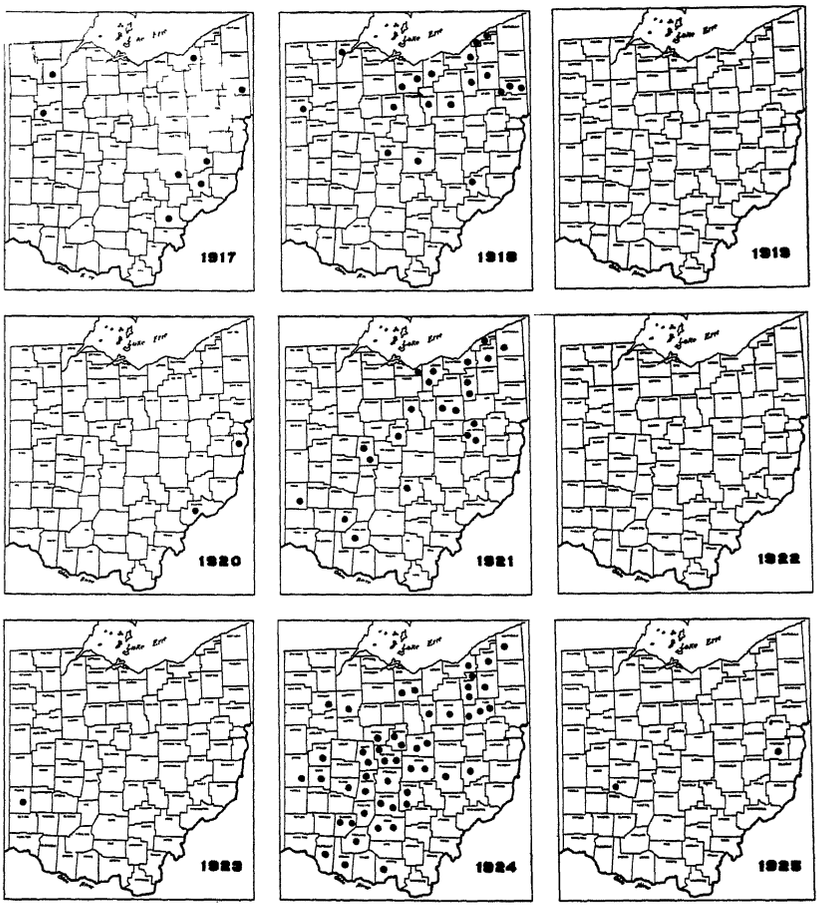



Fig. 8.—Maps showing source, locality and year of letters received at the Ohio Station pertaining to white grub injury during the period 1917 to 1925. The years 1918, 1921, and 1924 were the years of A Brood grub injury. It should be remembered that the year of grub injury is a year later than that of the beetle flight.

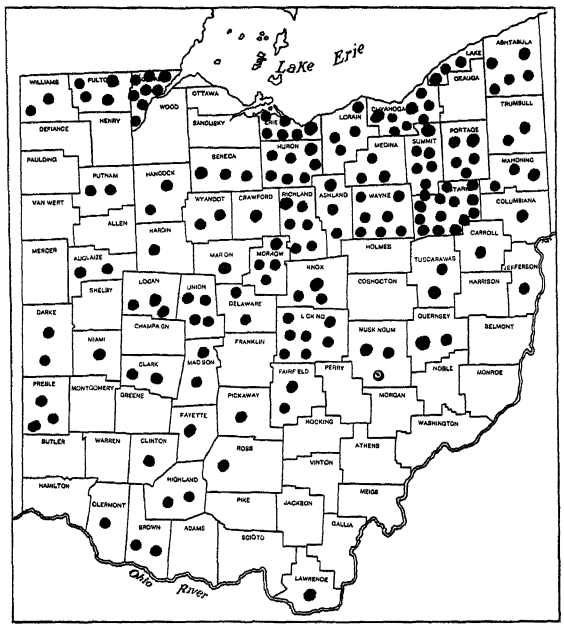



Fig. 9.–Map indicates letters received during Brood A grub damage years–1921, '24, '27, '30 and '33.

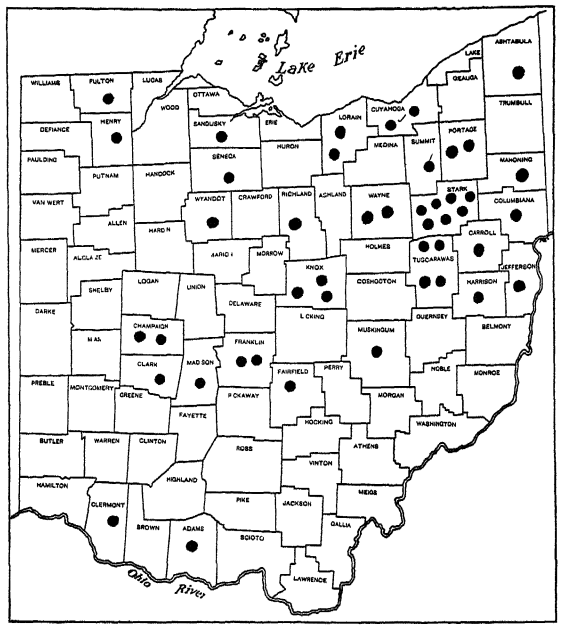



Fig. 10.–Map indicates letters received during Brood B grub damage years–1922, '25 '28, '31 and '34.

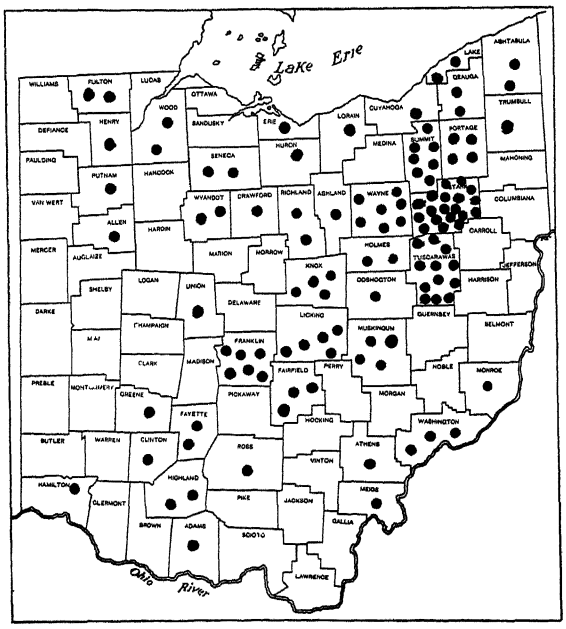



Fig. 11.–Map indicates letters received during Brood C grub damage years–1920, '23, '26, '29 and '32.

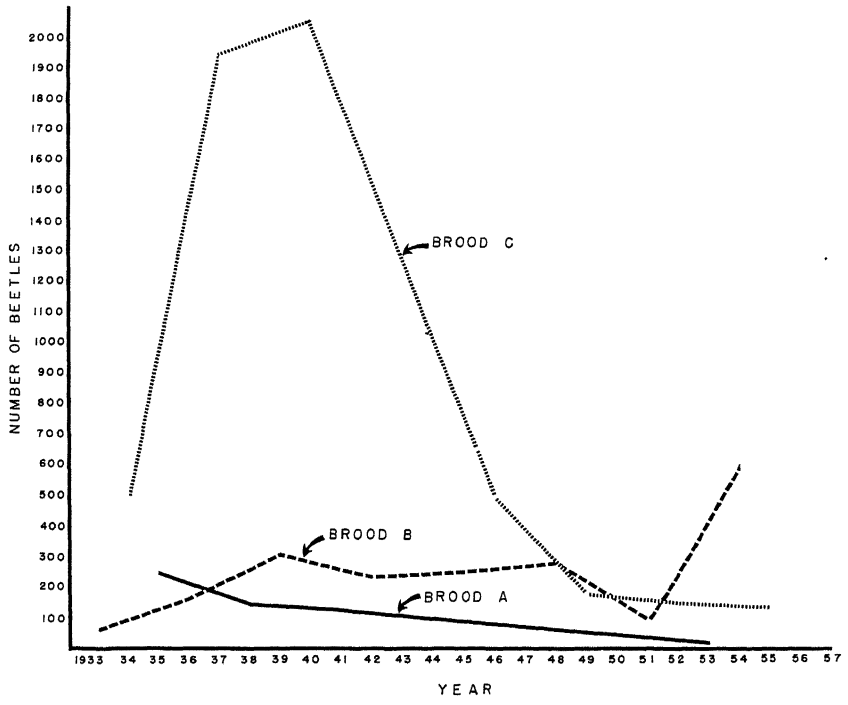



Fig. 12.–May beetles captured in light traps at Wooster, Ohio, during years 1933 to 1955, showing preponderance of Brood C in early part of period.

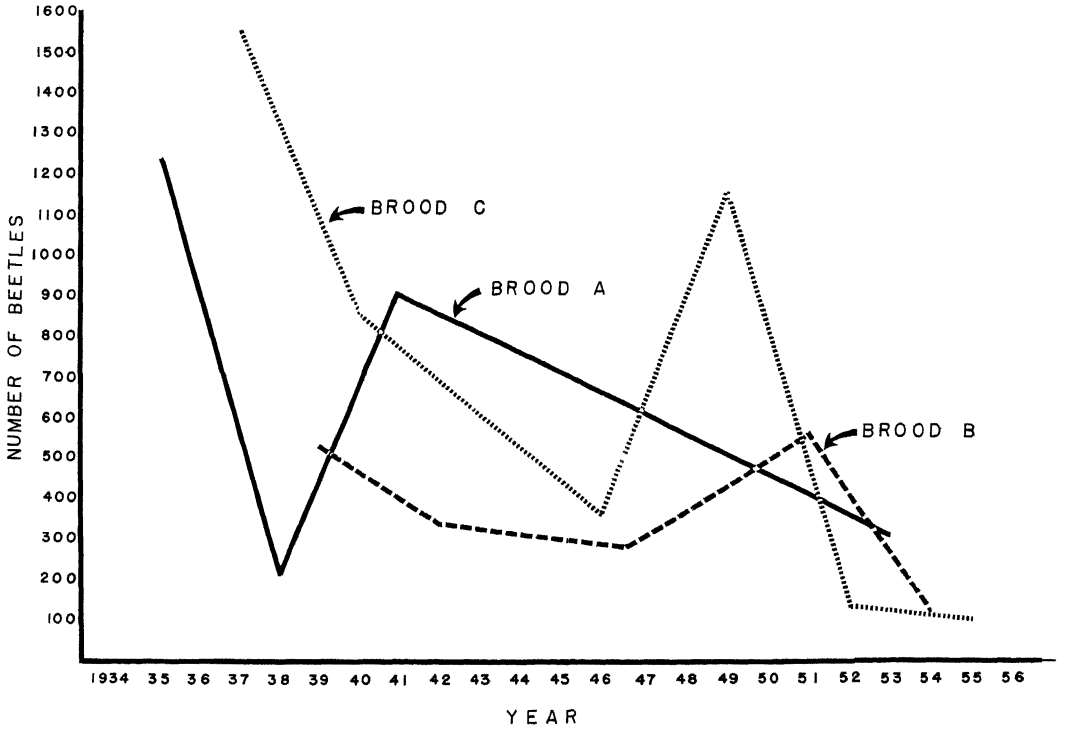



Fig. 13.–May beetles captured in light trap at Marietta, Ohio, during period 1935 to 1955, showing fluctuation in Brood abundance.

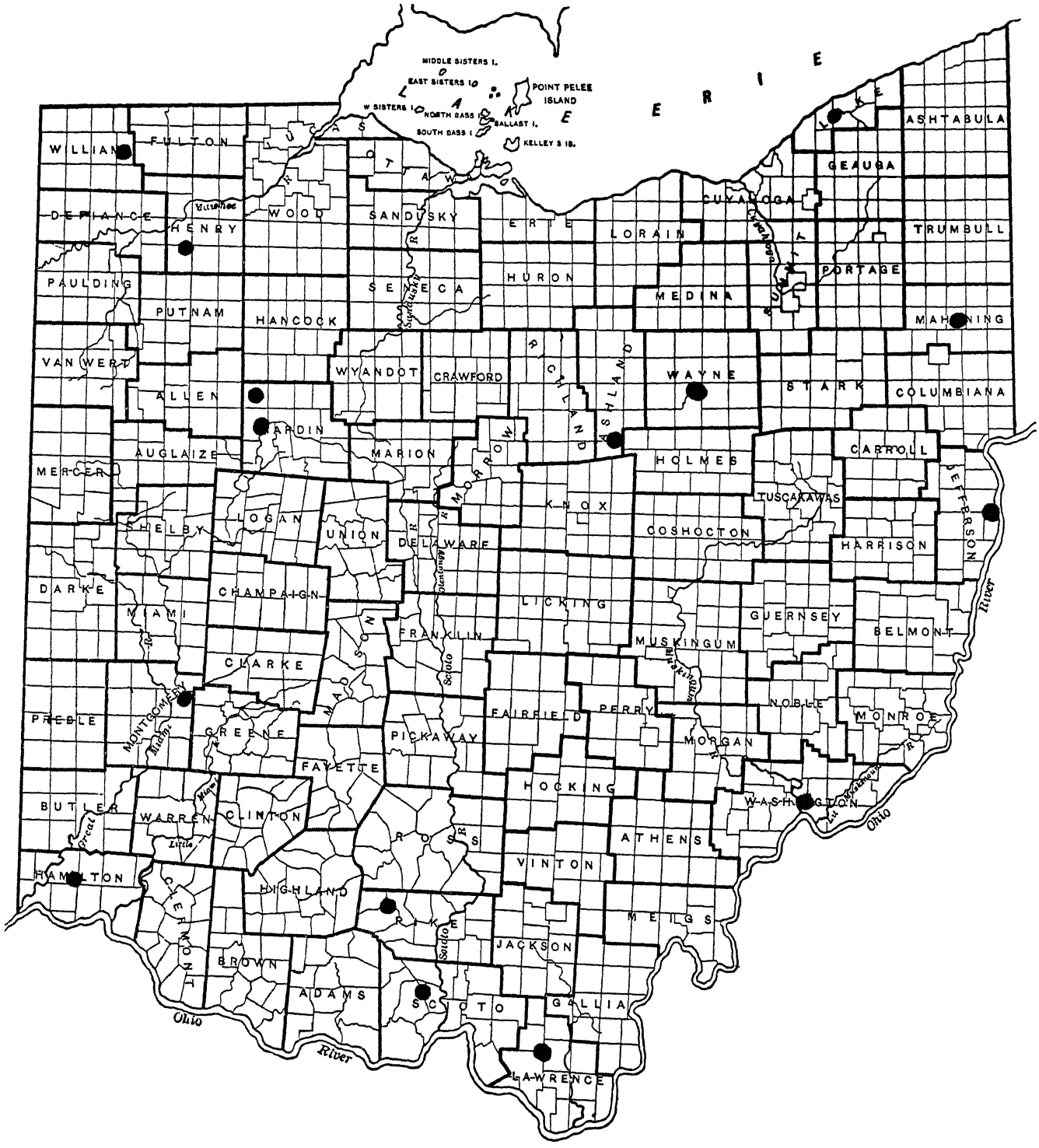



Fig. 14.—Location of light traps 1937–1942.

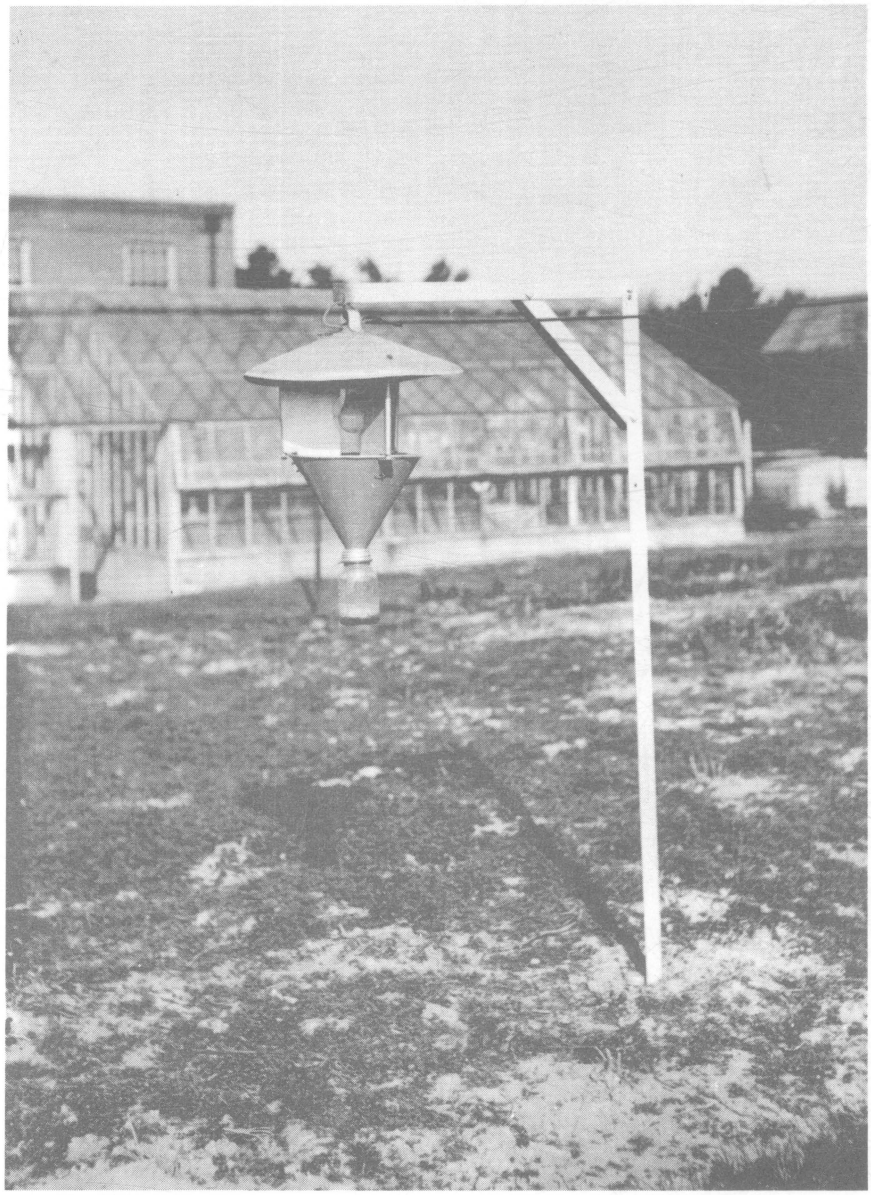


Fig. 15.—Standard light trap used for May beetle captures.


**Fig. 16.–Maps showing area in which defoliation of trees caused by May beetles was observed in 1937.**

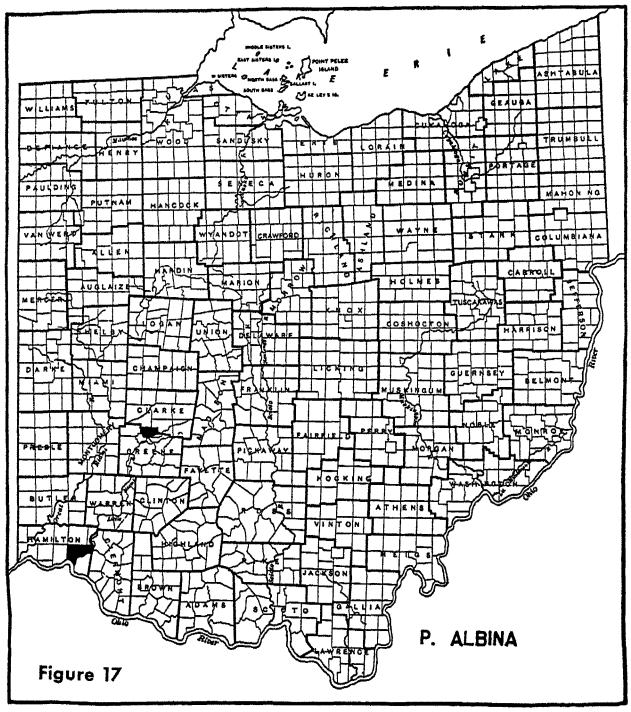



Figure 17

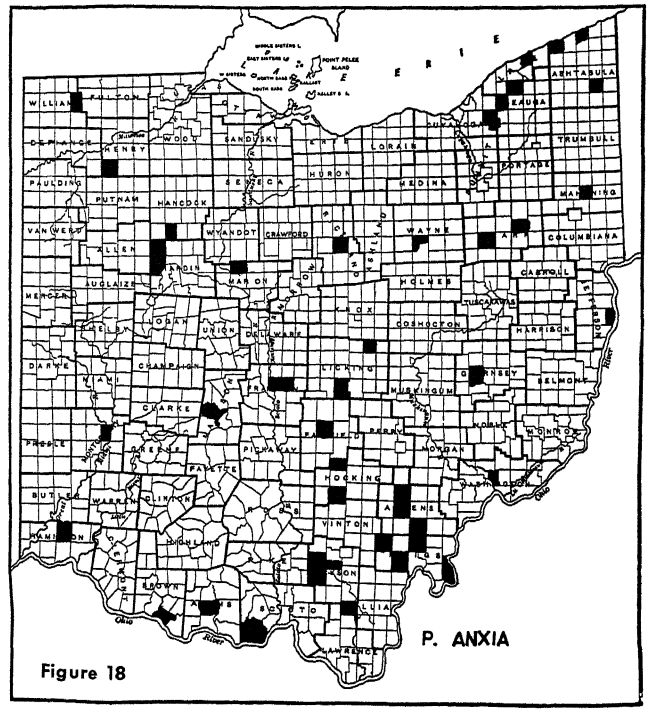



Figure 18

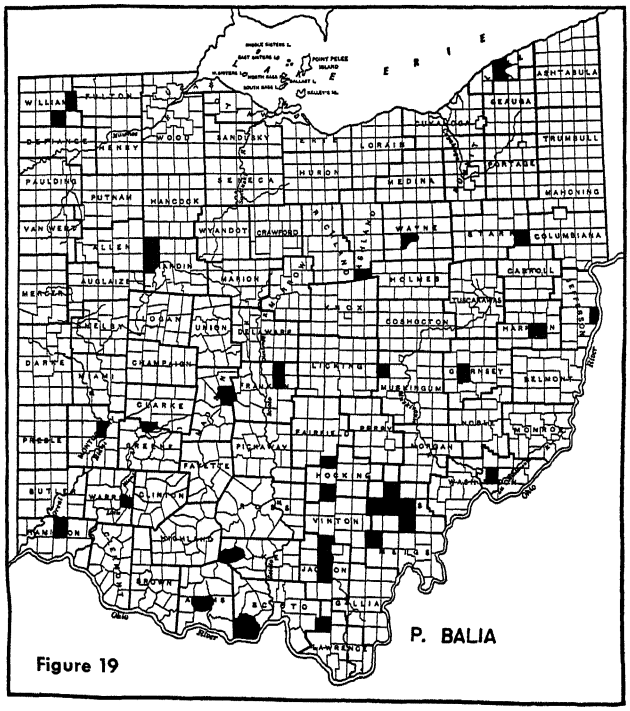



Figure 19

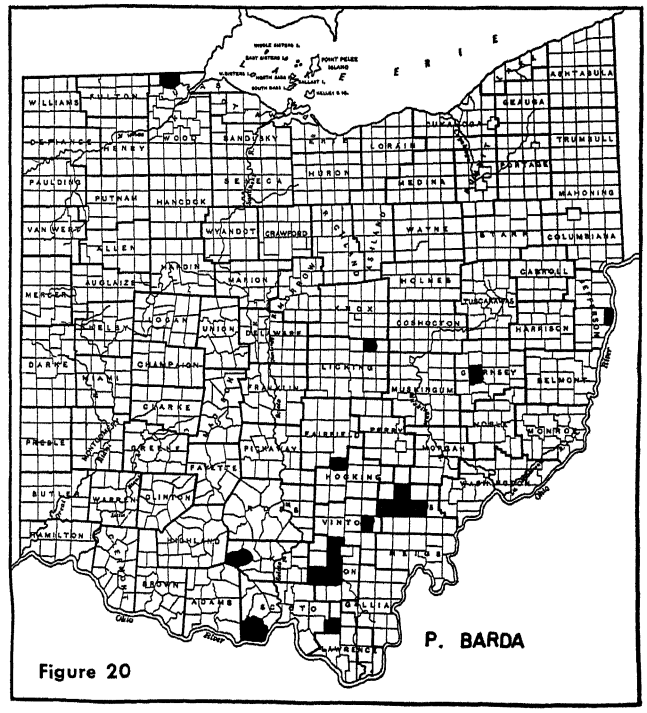



Figure 20

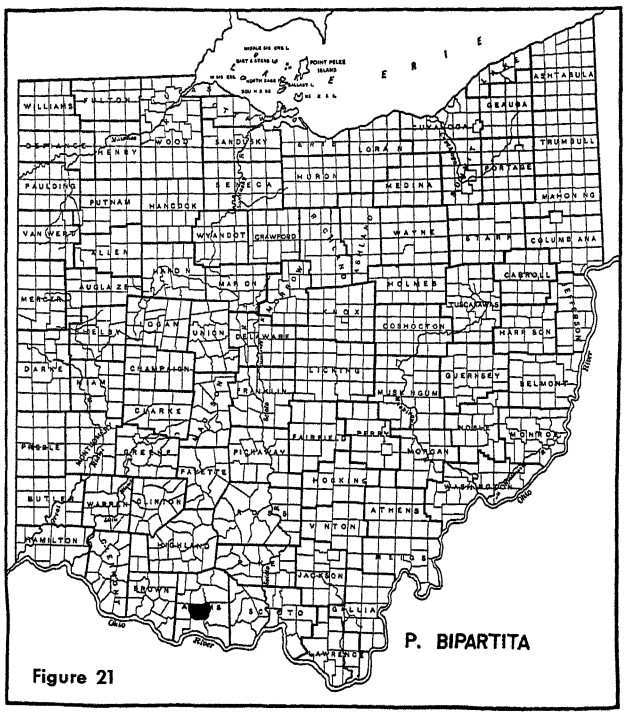



Figure 21

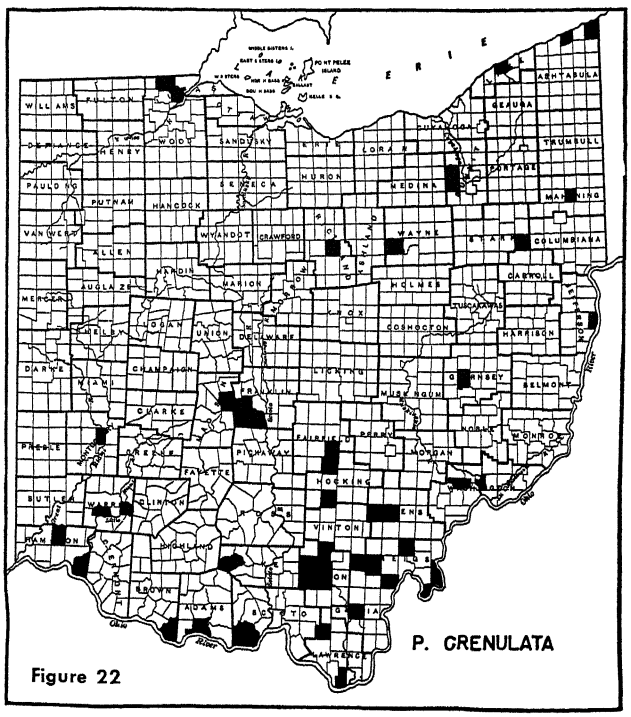
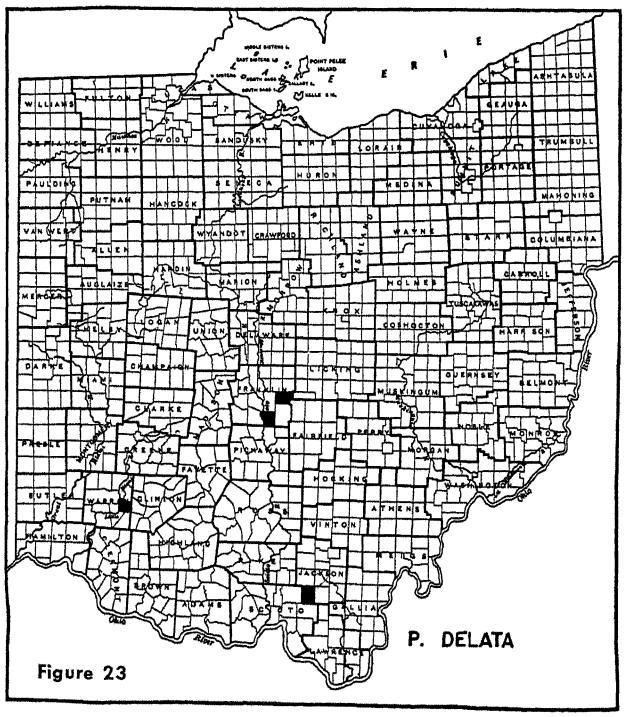



Figure 22

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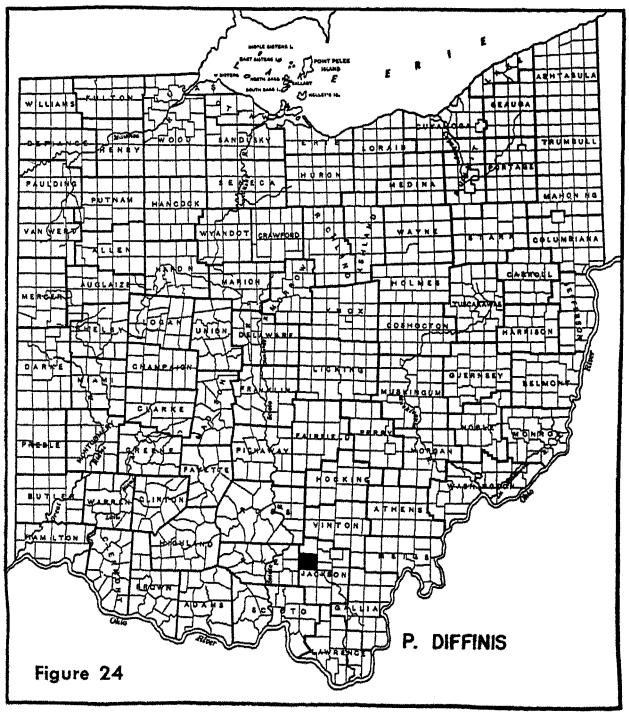
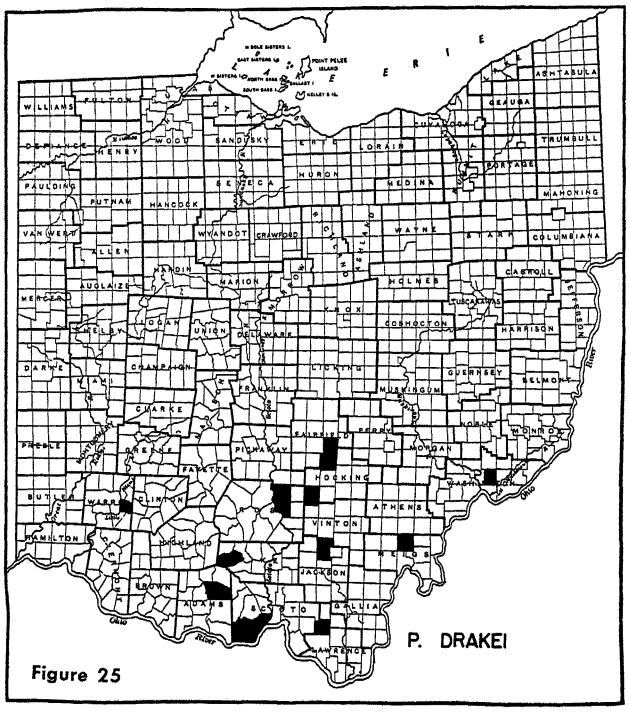



Figure 24

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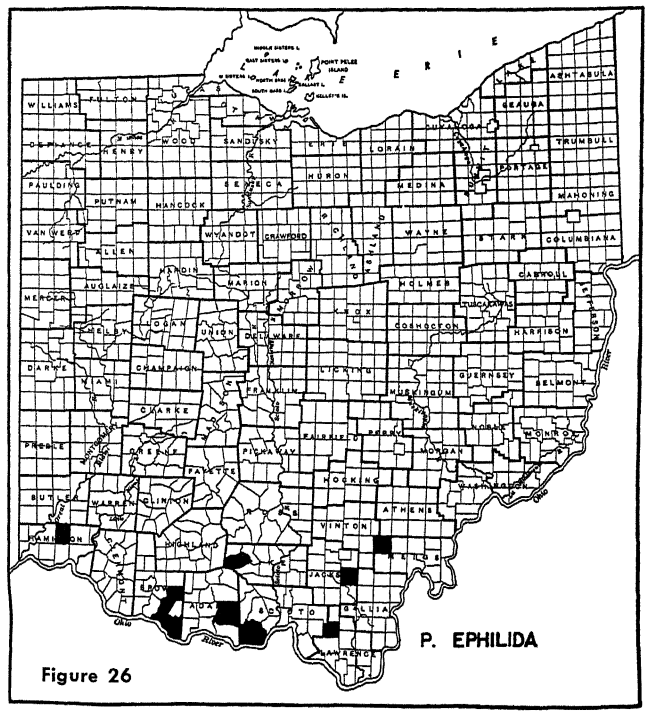


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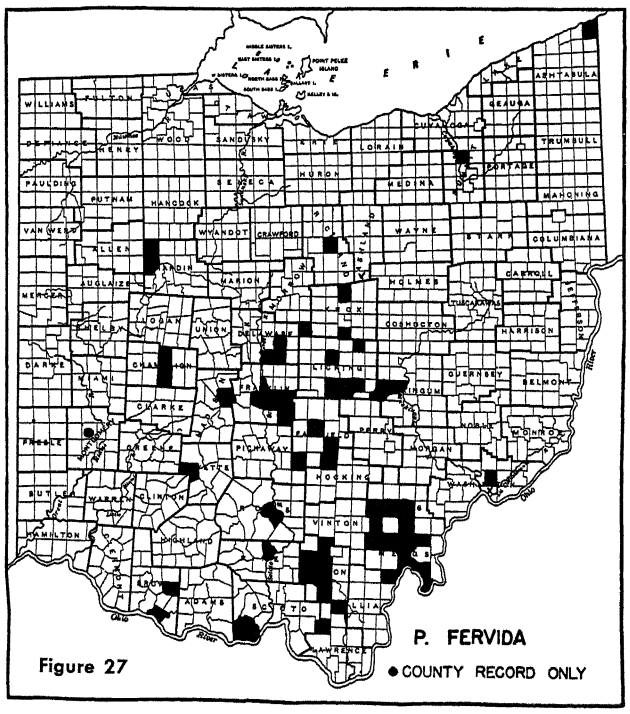
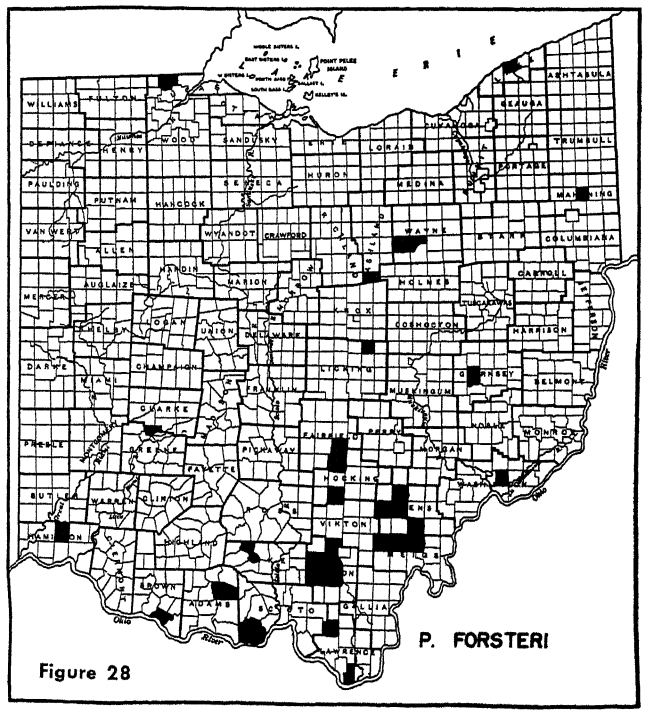



Figure 27

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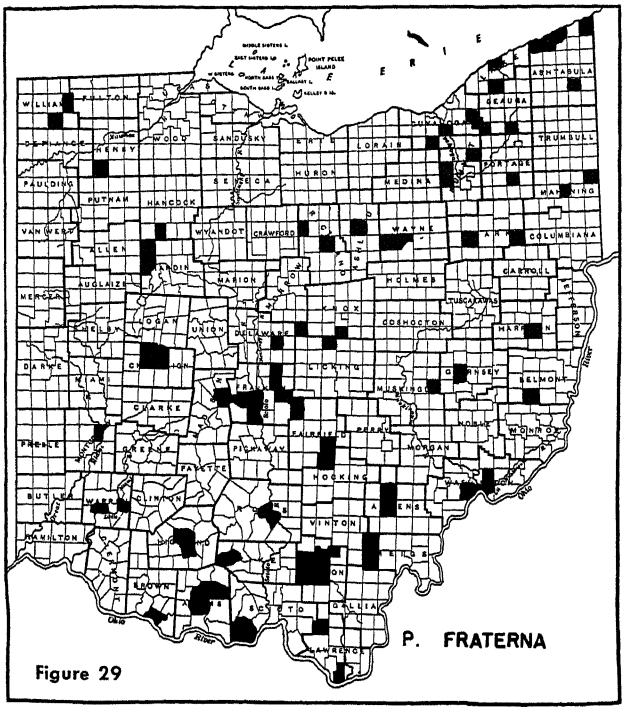


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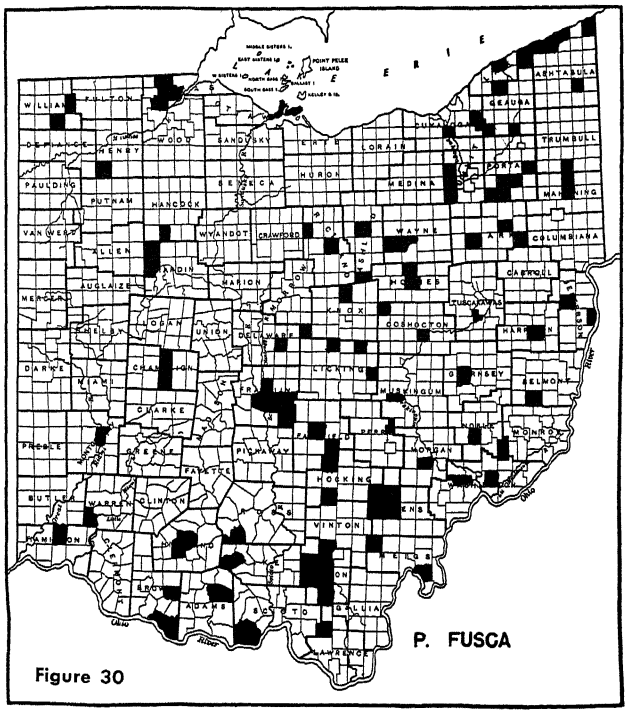



Figure 30

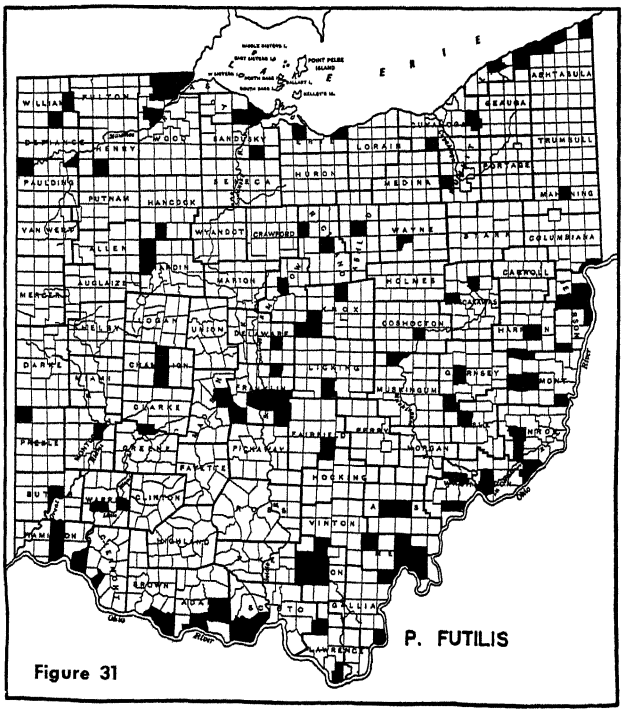



Figure 31

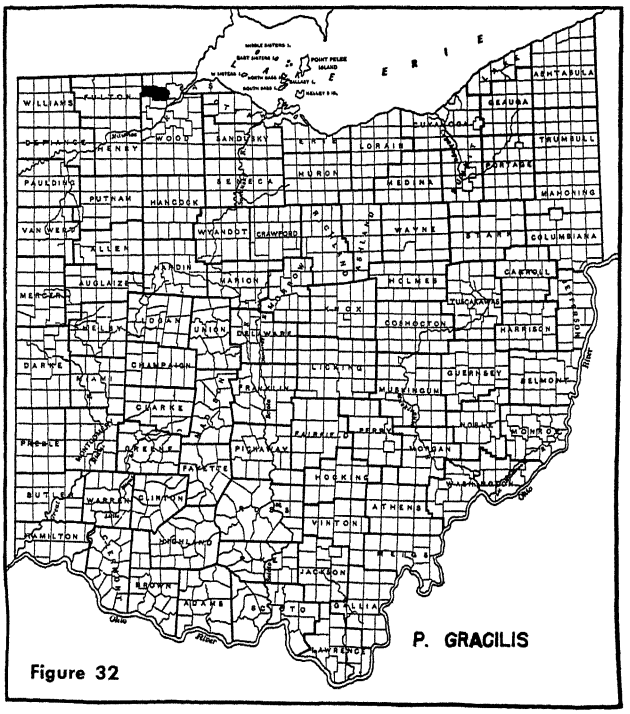
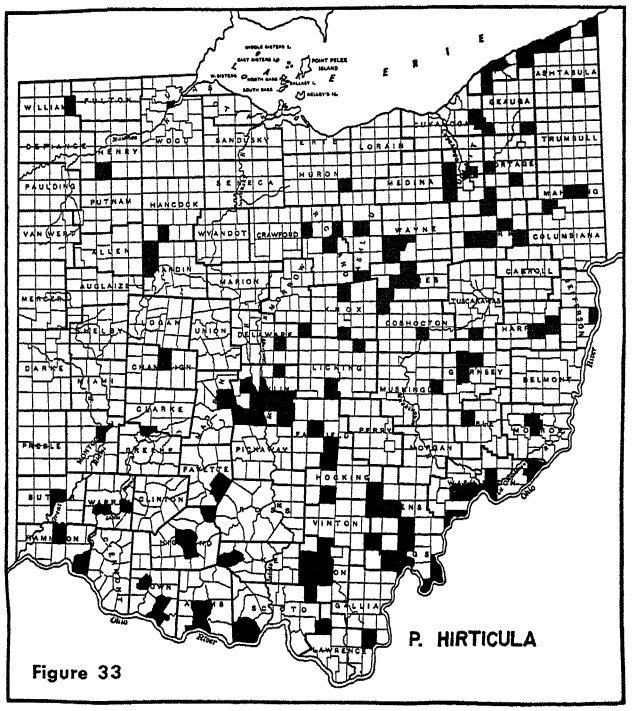



Figure 32

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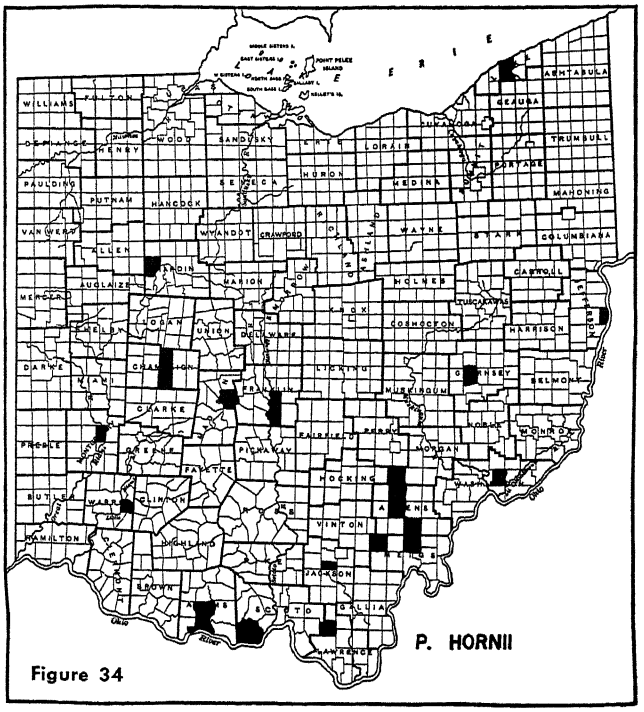
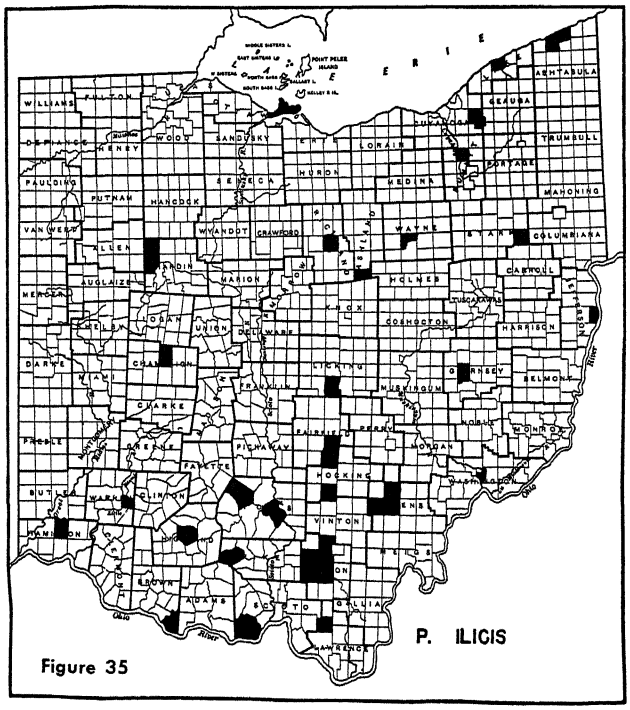



Figure 34

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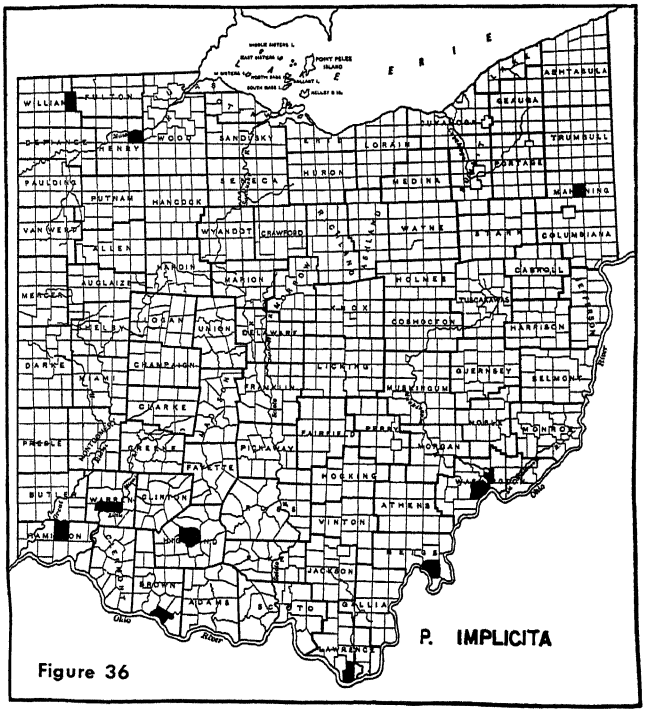


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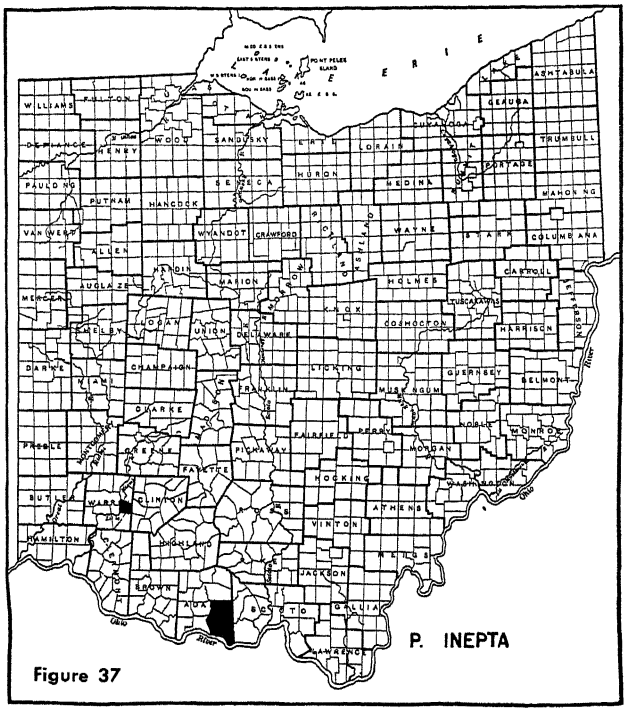


Figure 37

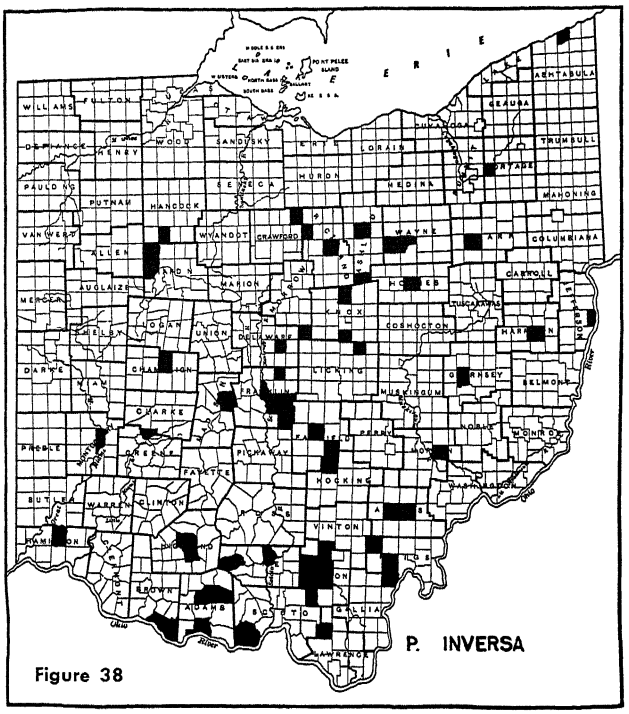


Figure 38

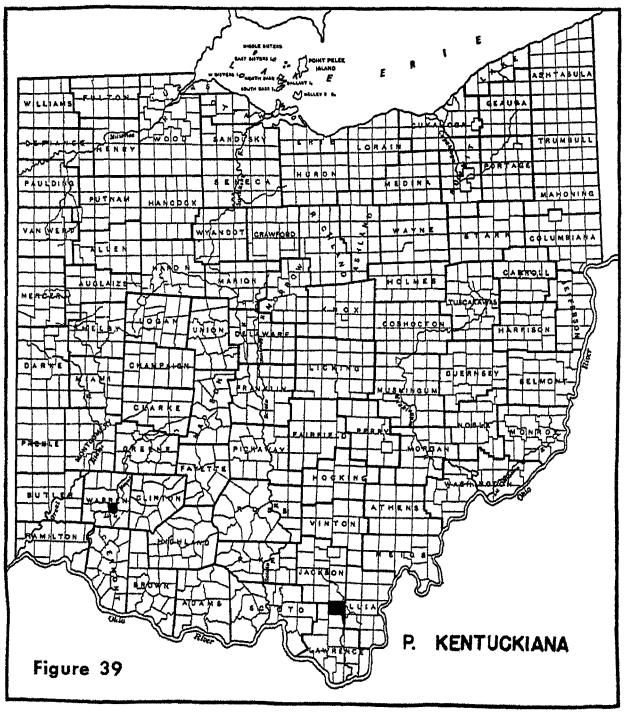


Figure 39

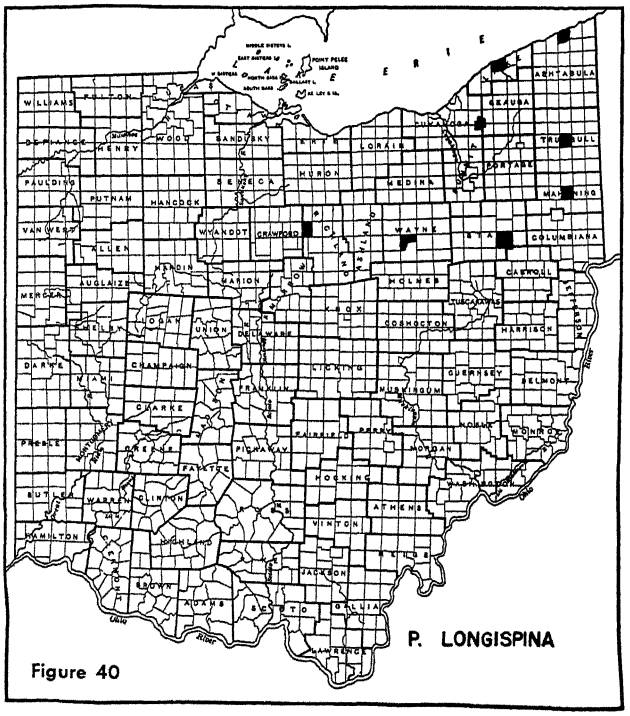


Figure 40

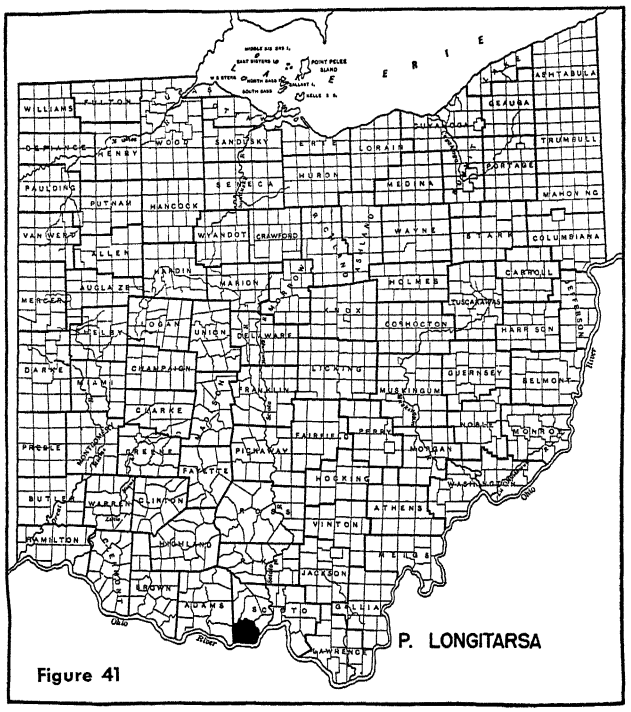


Figure 41

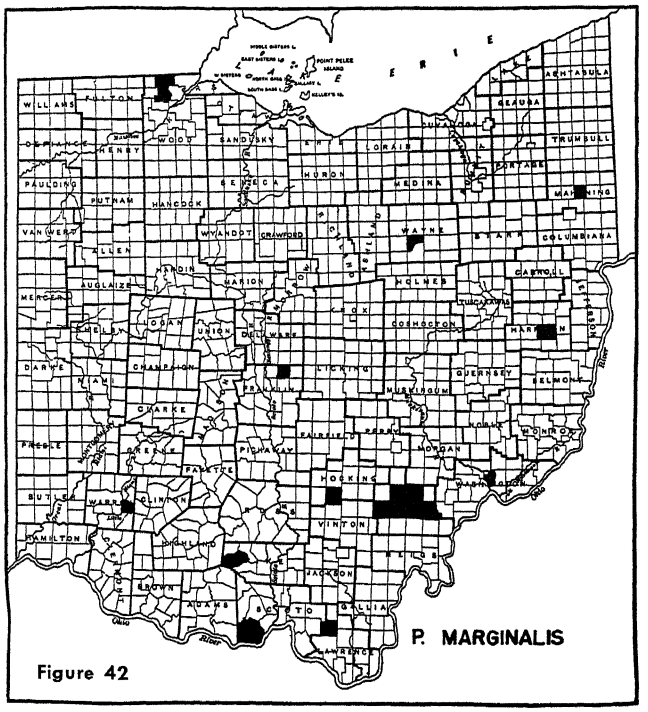


Figure 42

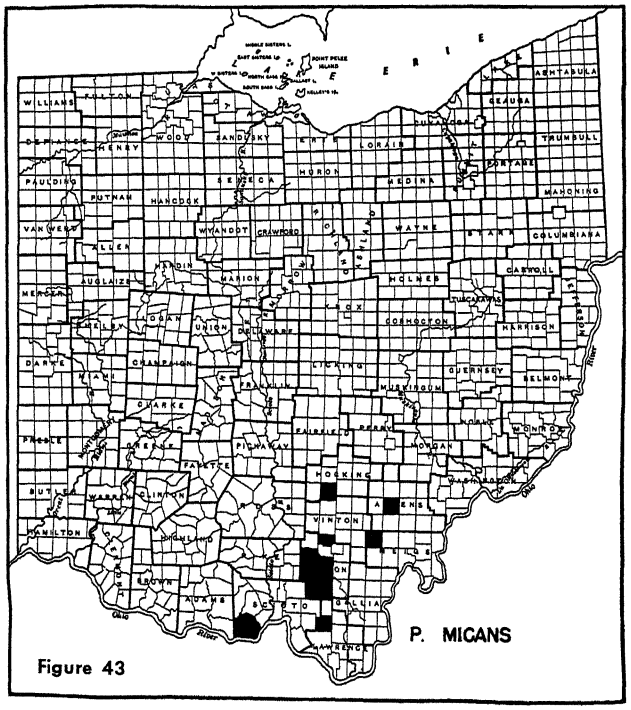


Figure 43

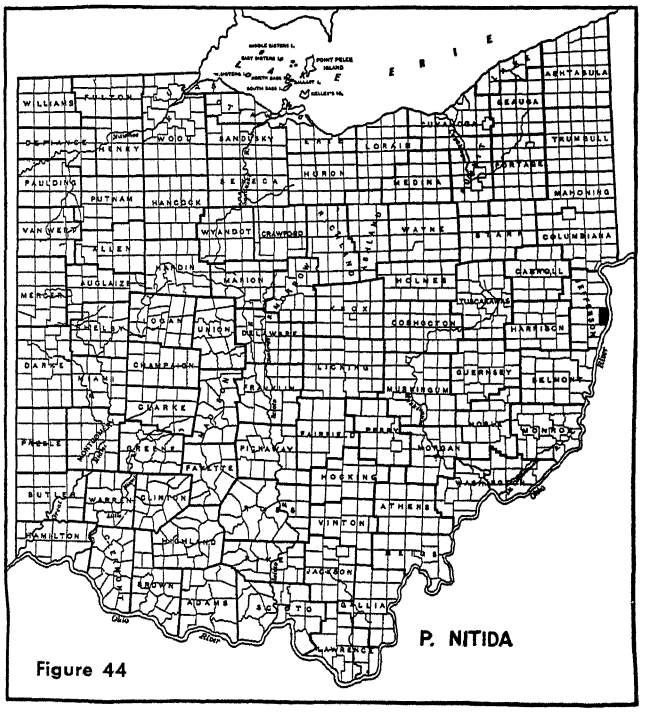


Figure 44

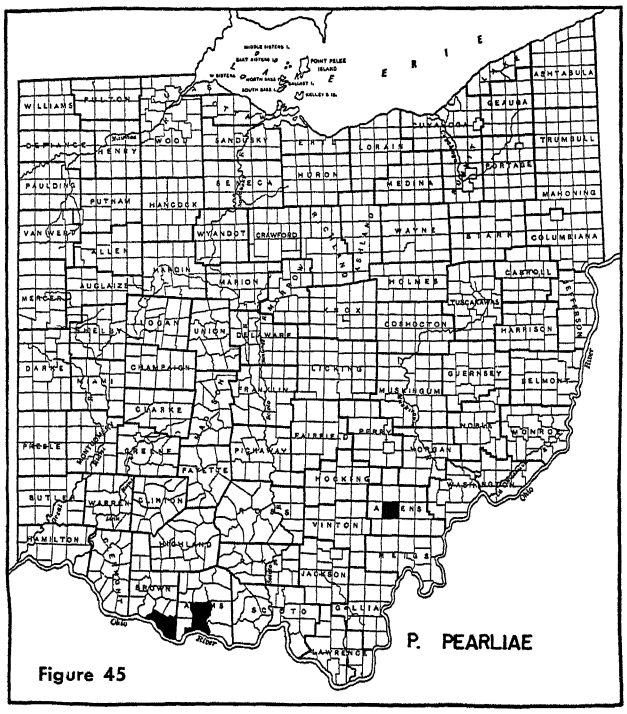


Figure 45

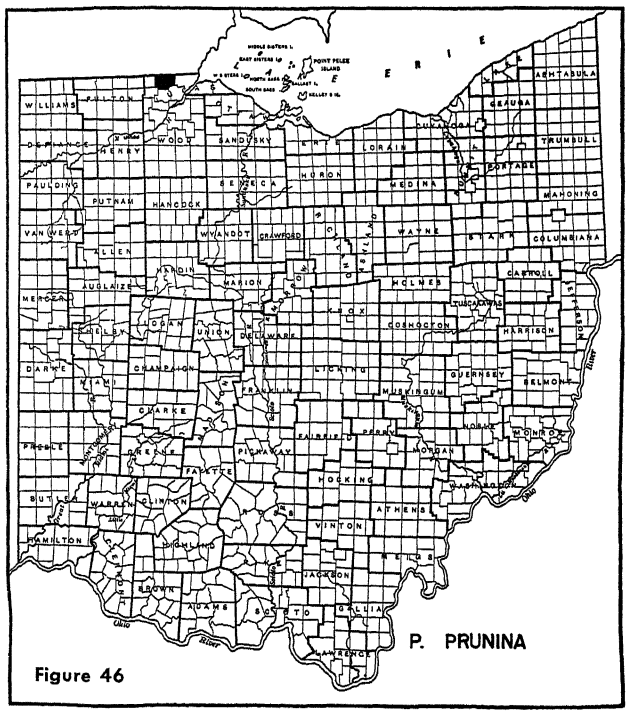


Figure 46

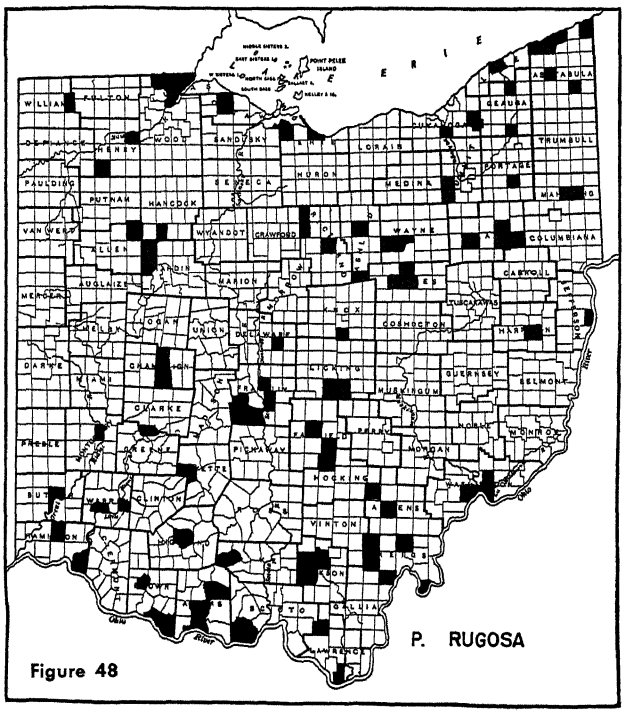


Figure 48

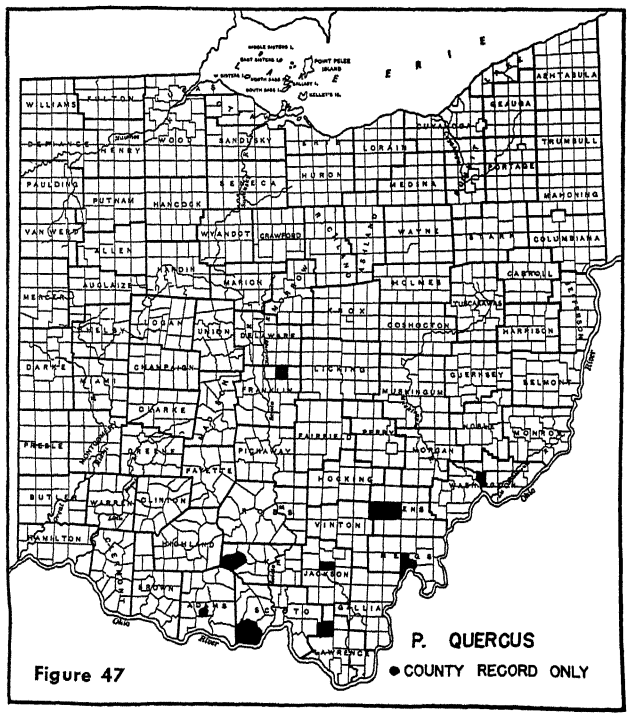


Figure 47

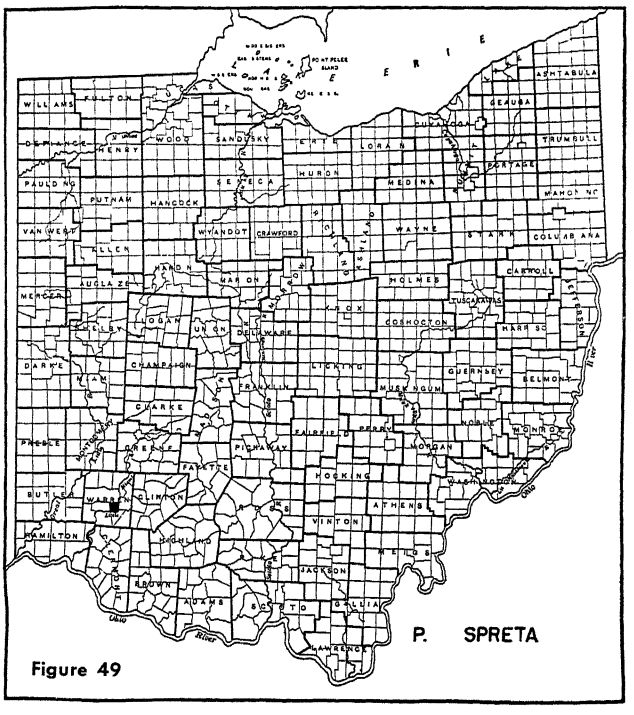


Figure 49

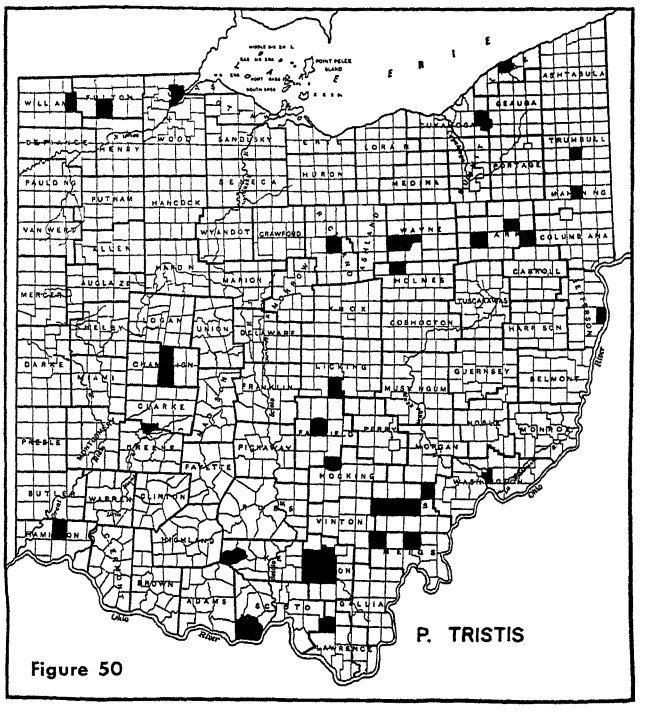


Figure 50

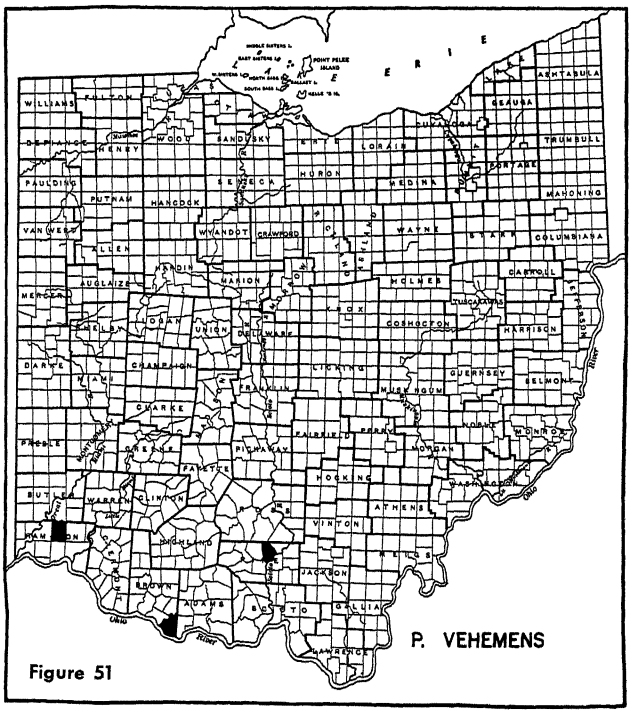


Figure 51

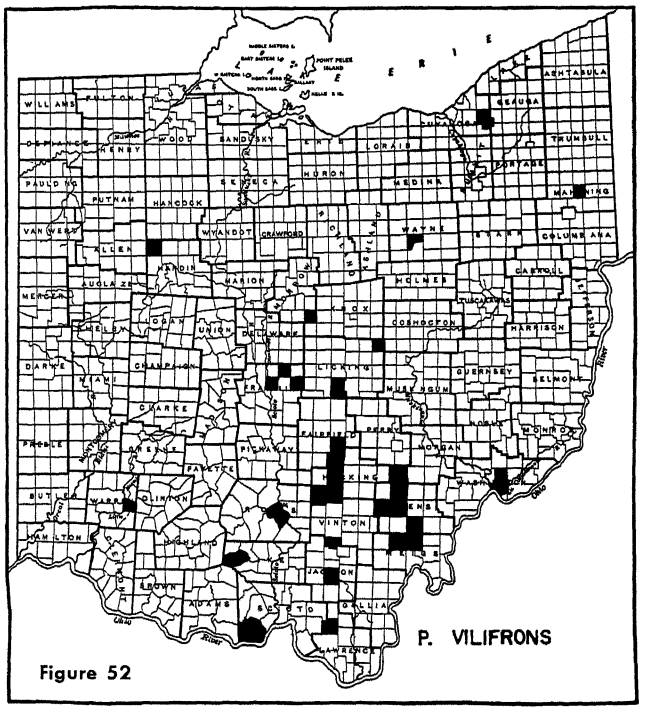


Figure 52